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Introduction

Welcome to another course in the STEP series, **S**iemens **T**echnical **E**ducation **P**rogram, designed to help our distributors and customers better understand Siemens Industry, Inc. products. This course covers **Basics of Panelboards**.

Upon completion of **Basics of Panelboards,** you will be able to:

- Explain the role of panelboards in a power distribution system
- Define a panelboard according to the *National Electrical Code* ®
- Distinguish between a lighting and appliance panelboard and a power panelboard
- Explain the need for circuit protection
- Distinguish between a main breaker panelboard and a main lug only panelboard
- Identify the most common power supply systems for panelboards
- Explain the use of panelboards as service-entrance equipment
- Describe the proper grounding techniques of service entrance and downstream panelboards
- Describe the five Siemens P series panelboard models
- Identify key ratings of Siemens P series panelboards
- Identify Siemens P series panelboard options
- Identify additional Siemens panelboard types

This knowledge will help you better understand panelboard applications. In addition, you will be better prepared to discuss panelboards with others. You should complete **Basics of Electricity** and **Basics Circuit Breakers** before attempting **Basics of Panelboards**. An understanding of many of the concepts covered in **Basics of Electricity** and **Basics of Circuit Breakers** is required for **Basics of Panelboards**.

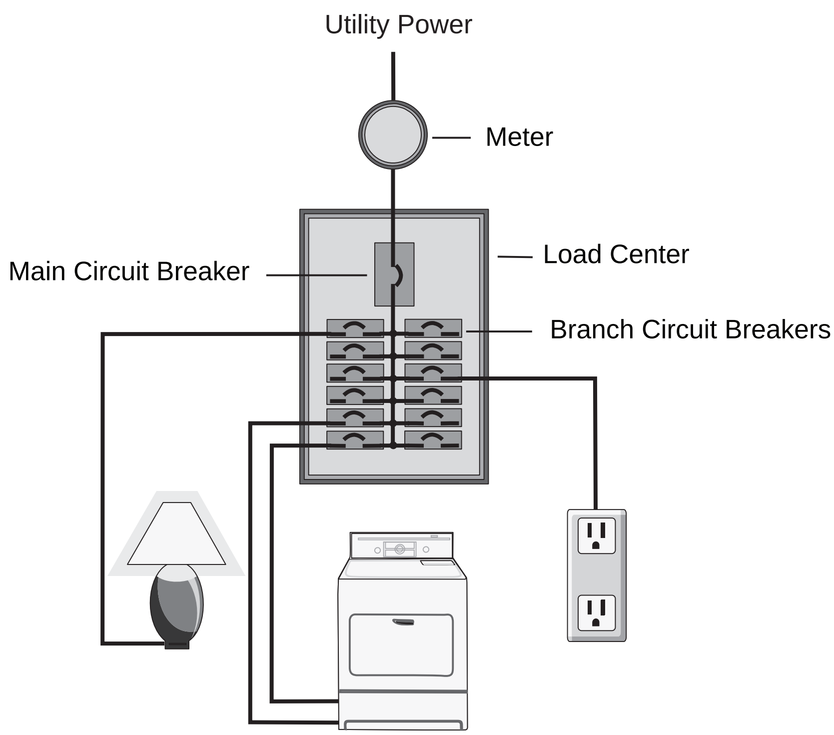
After you have completed this course, if you wish to determine how well you have retained the information covered, you can complete a final exam online as described later in this course. If you pass the exam, you will be given the opportunity to print a certificate of completion from your computer.

Distribution Systems

Power distribution systems are used in every residential, commercial, and industrial building to safely control the distribution of electrical power throughout the facility.

Residential Power Distribution

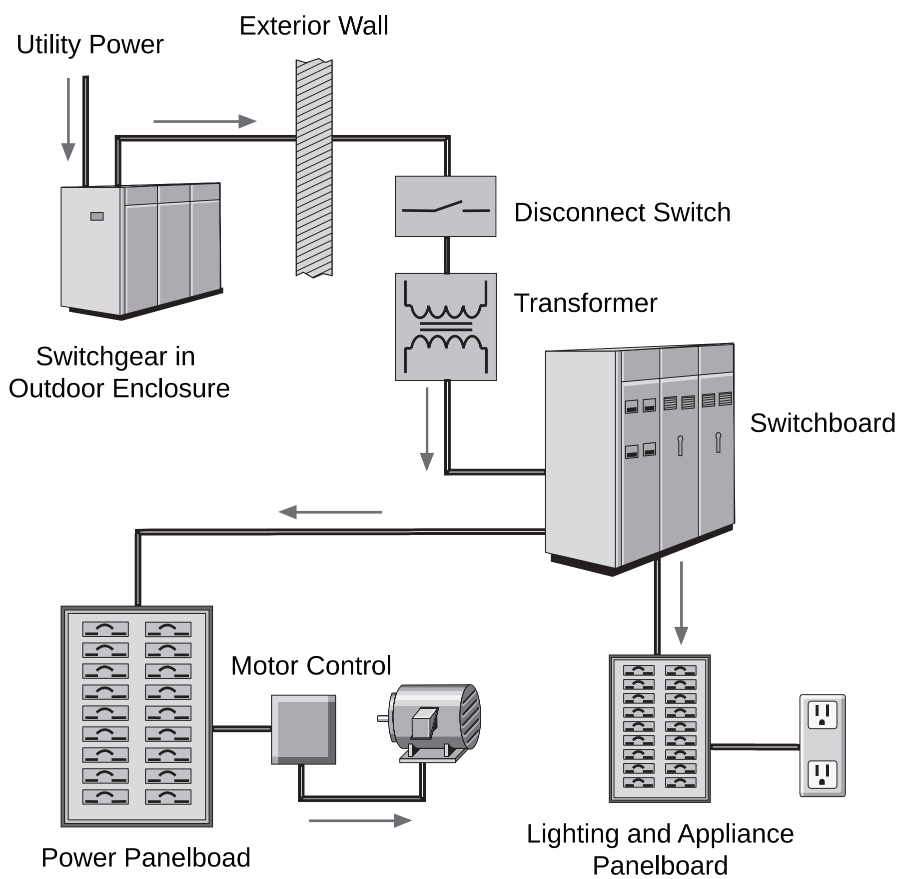
Most of us are familiar with the power distribution system found in the average home. Power, purchased from a utility company, enters the house through a metering device. The power is then distributed by a load center to various branch circuits for lighting, appliances, and electrical outlets.



Commercial and Industrial Power Distribution

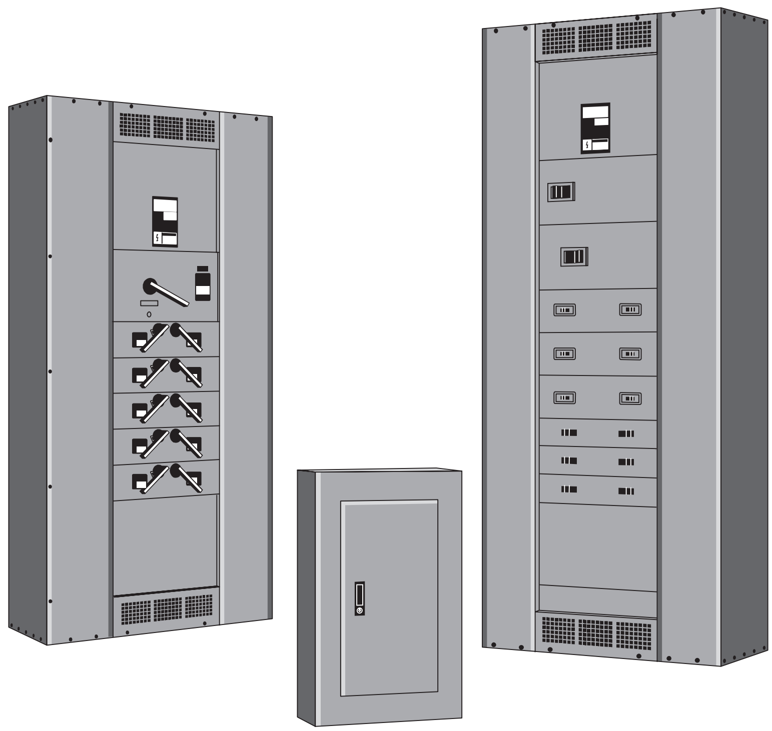
Power distribution systems used in multi-family, commercial, and industrial facilities are more complex. A power distribution system consists of metering devices to measure power consumption, main and branch disconnects, protective devices, switching devices to start and stop power flow, conductors, and transformers. Power may be distributed through various switchboards, transformers, and panelboards.

Good distribution systems don't just happen. Careful engineering is required so that the distribution system safely and efficiently supplies adequate electric service to existing loads and has expansion capacity for possible future loads.



Panelboards

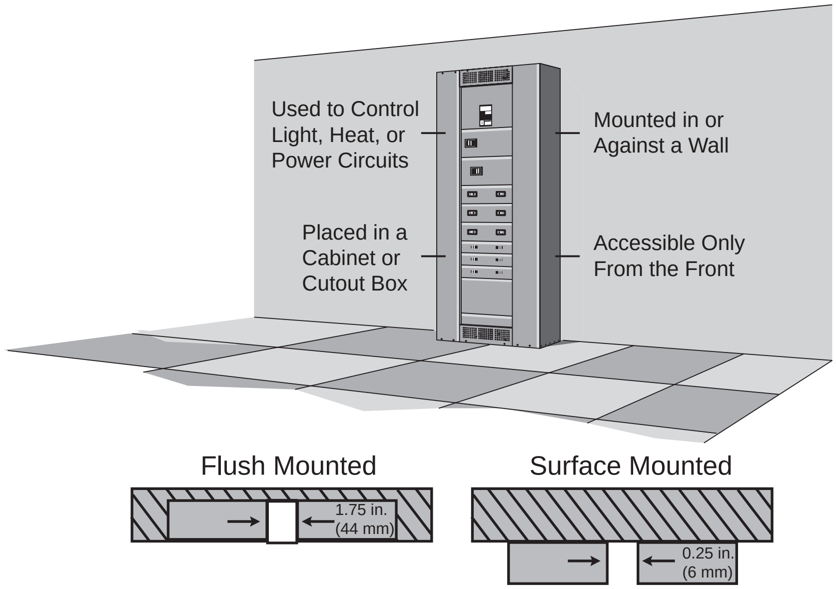
Electrical distribution systems, whether simple or complex, typically include **panelboards**, the focus of this course. Even the load center used in a home is a type of panelboard. However, the focus of this course is on panelboards used in commercial and industrial facilities.



Panelboard Definition

A panelboard is a type of enclosure for overcurrent protection devices and the busses and connections that provide power to these devices and their associated circuits. According to the *National Electrical Code® (NEC®)*, a panelboard is:

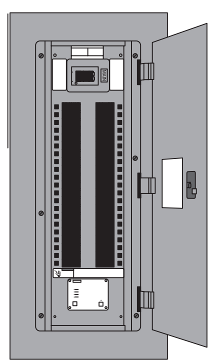
- Used to control light, heat, or power circuits
- Placed in a cabinet or cutout box
- Mounted in or against a wall
- Accessible only from the front



For additional information, refer to *National Electrical Code*® Article 408, Switchboards and Panelboards.

Panelboards are frequently divided into two categories:

- **Lighting and appliance branch-circuit panelboards**
- **Power panelboards** (also called **distribution panelboards**)



Lighting and Appliance Panelboard

Power Panelboards

Prior to the 2008 *National Electrical Code*®, the distinction between these two panelboard types was described in *NEC*® Articles 408.34 and 408.35. These articles placed restrictions on lighting and appliance panelboards and indicated that panelboards that did not comply with these restrictions were defined as power panelboards.

For example, a lighting and appliance, branch-circuit panelboard had to have more than ten percent of its overcurrent protection devices (not including main devices) protecting lighting and appliance branch circuits. A lighting and appliance branch circuit is one with a connection to the panelboard neutral and an overcurrent protection device rated for 30 amps or less. For the purpose of this definition, each pole of a device is considered as one device. Additionally, a lighting and appliance panelboard was allowed a maximum of 42 overcurrent protection devices (poles) in any one cabinet or cutout box.

Articles 408.34 and 408.35 and their associated restrictions were removed from the *National Electrical Code*® beginning with the 2008 code. However, the terms lighting and appliance panelboard (also called a lighting panel) and power panelboard (also called a power panel or distribution panelboard) are still widely used.

Review 1

1. A ________ system safely controls the distribution of electrical power throughout a facility.

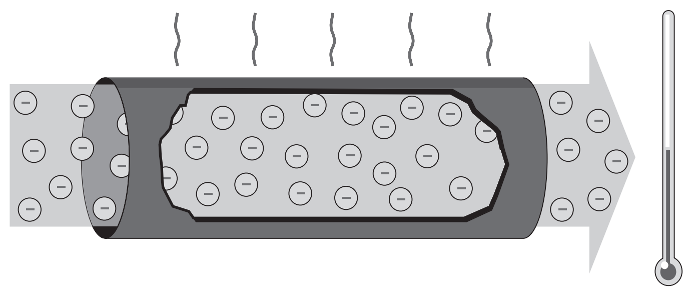
2. Which of the following descriptions is not correct according to the *NEC*® definition for a panelboard?

   a. Controls light, heat, or power circuit
   b. Accessible from the front or rear
   c. Mounted in or on a wall
   d. Placed in a cabinet or cutout box

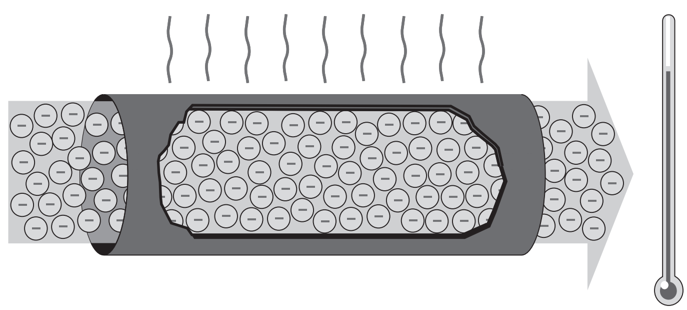
3. The articles that differentiate a lighting and appliance branch-circuit panelboard and a power panelboard were removed from the *NEC*® beginning with the ________ code.

Overcurrent Protection Devices

Because current flow in a conductor always generates heat, the greater the current flow, the hotter the conductor. Excess heat is damaging to electrical conductors. For that reason, conductors have a rated continuous current carrying capacity or **ampacity**. Current beyond the rated capability of a conductor is referred to as **overcurrent**. Overcurrent can result from a short circuit, an overload, or a ground fault.



Normal Current Flow



Excessive Current Flow

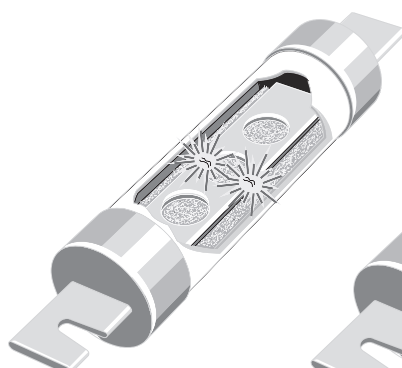
A **short circuit** occurs when two bare conductors touch causing the resistance between the conductors to drop significantly. This reduction in resistance causes an immediate and destructive increase in current. An **overload** is a typically a much lower current than a short circuit. An overload occurs when too many devices are connected to a circuit or when electrical equipment is made to work beyond its rated capabilities. Finally, a **ground fault** occurs when current takes an undesired path to ground. The level of ground fault current depends on the resistance of the path and the amount of voltage applied.

Overcurrent protection devices are used to protect conductors from excessive current flow. Some overcurrent protection devices only provide protection in the event of a short circuit, some provide both short circuit and overload protection, and some devices provide protection in the event of any of the three overcurrent types.

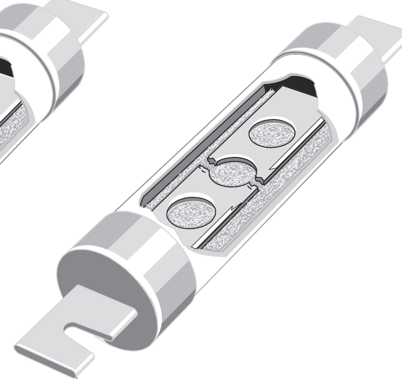
Circuit protection would be unnecessary if overcurrents could be eliminated. Unfortunately, overcurrents do occur and, when an overcurrent occurs, a protection device must automatically disconnect the electrical equipment from the voltage source. An overcurrent protection device must be also able to recognize the difference between a small overcurrent and a short circuit and respond in the proper way. A small overcurrent is often allowed to continue for a short time, but, as the current magnitude increases, the protection device must respond faster. Short circuits must be interrupted immediately.

Fuse

A **fuse** is one type of overcurrent protection device. A fuse is a one-shot device. The heat produced by overcurrent causes the current carrying element to melt open, disconnecting the load from the source voltage.



Fuse During Fault



Fuse After Fault

Non-time-delay Fuses

Non-time-delay fuses provide excellent short circuit protection. When an overcurrent occurs, heat builds up rapidly in the fuse. Non-time-delay fuses usually hold 500% of their rating for approximately one-fourth second, after which the current-carrying element melts. This means that these fuses cannot be used in motor circuits, which often have large in-rush currents when a motor starts.

Time-delay Fuses

Time-delay fuses provide overload and short circuit protection. Time-delay fuses used in motor applications usually allow several times the rated current for a short time to allow motors to start without blowing the fuse.

Fuse Classes

Underwriters Laboratories (UL) establishes and standardizes basic performance and physical specifications for products that undergo its safety test procedures. Among the standards developed by UL are standards for **classes of low voltage fuses** (fuses with voltage ratings of 600 volts or less). The following table shows the fuse classes most commonly found in panelboards.

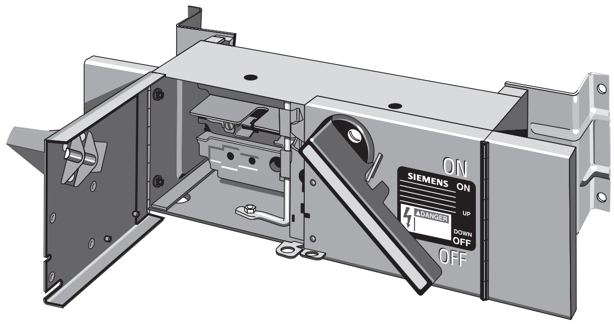
UL Fuse Class	Voltage Ratings	Ampere Ratings	Interrupting Ratings
H	250 and 600 VAC	up to 600 A	10 kA
J	600 VAC	up to 600 A	200 kA
	300 VDC	up to 30 A	100 kA
	500 VDC	up to 600 A	100 kA
L	600 VAC	601 to 6000 A	200 kA
	500 VDC	601 to 3000 A	100 kA
RK-1	250 and 600 VAC	up to 600 A	200 kA
	250 VDC	up to 600 A	100 kA
	600 VDC	up to 600 A	100 kA
RK-5	250 and 600 VAC	up to 600 A	200 kA
	300 VDC	up to 30 A	20 kA
	600 VDC	35 to 400 A	20 kA
T	300 VAC	up to 1200 A	200 kA
	600 VAC	up to 800 A	200 kA
	160 VDC	up to 1200 A	50 kA
	300 VDC	up to 1200 A	100 kA

Fuses are grouped into **classes** based on their operating and construction characteristics. Each class has an interrupting rating, which is the maximum current the fuse is capable of safely interrupting. Fuses also have maximum continuous current and maximum voltage ratings.

When selecting fuses, it is a good idea to refer to the fuse manufacturer's application data to make sure that a specific fuse is appropriate for the type of loads involved.

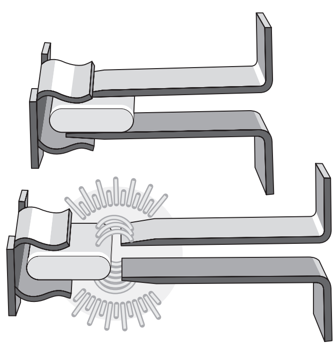
Fusible Disconnect Switch

A **fusible disconnect switch** is one type of device used on panelboards to provide overcurrent protection. Fuses located in the switch are selected to handle the specified levels of current and voltage and to provide the appropriate interrupting rating.

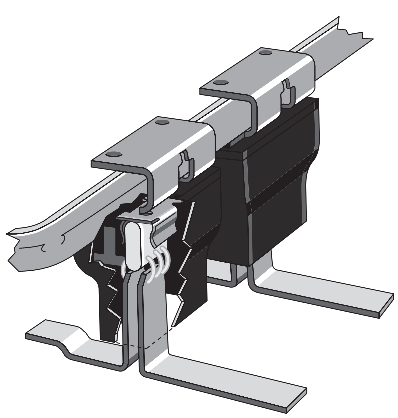


Siemens Vacu-Break fusible switches, through 600 A, feature a **Clampmatic action** that holds the current carrying contact surfaces in a vise-like grip. Heat build-up due to current is minimized.

When the switch is moved to the OFF position, the movable contact snaps from between the jaws providing a quick, clean break. Twin arcs are produced which are smaller and extinguish quicker than a single arc produced by other designs.



The contacts are surrounded by an **enclosed arc chamber** which absorbs much of the heat from the arching. The enclosed chamber limits oxygen to more rapidly cool and extinguish arcs.

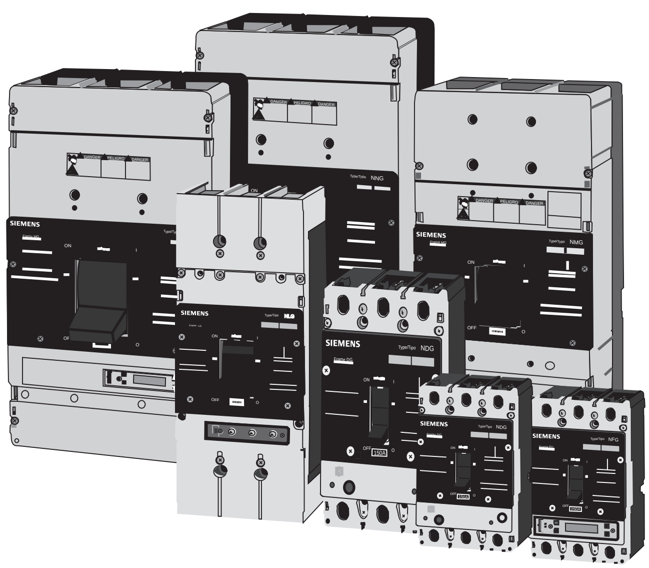


High Contact Pressure Fusible Switch

Siemens **high contact pressure (HCP) fusible switches** have continuous current ratings from 400 A to 1200 A.

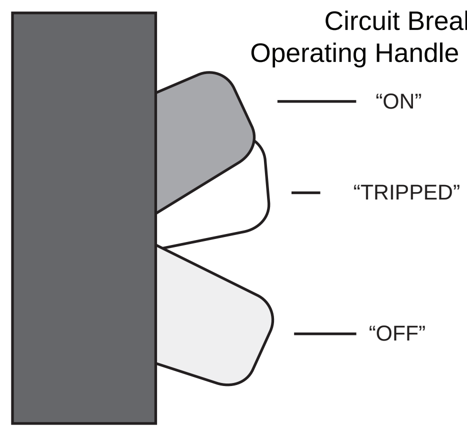
Circuit Breaker

Another device used for overcurrent protection is a **circuit breaker**. Although some circuit breakers do incorporate fuses, most do not, but, like a fusible switch, a circuit breaker provides overcurrent protection and a manual means of controlling power distribution.

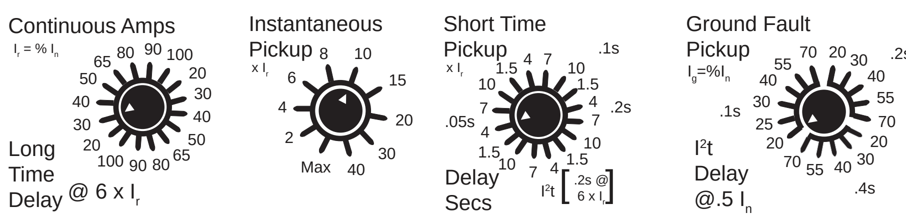


When an overcurrent occurs, the circuit breaker trips to remove power from the circuit. The greater the overcurrent, the more rapidly the circuit breaker trips. Once the overcurrent condition has been corrected, a simple flip of the breaker's operating handle restores the circuit.

The ability to restore a circuit without replacing a fuse is one of the key advantages of a circuit breaker. However, circuit breakers have other advantages as well. For example, some circuit breakers have adjustments or a replaceable trip unit to allow the level of fault current required to trip the breaker to be set to match the application. Some circuit breakers also have communication capability to allow information to be sent to power monitoring equipment or display devices.



Circuit Breaker
Operating Handle Positions



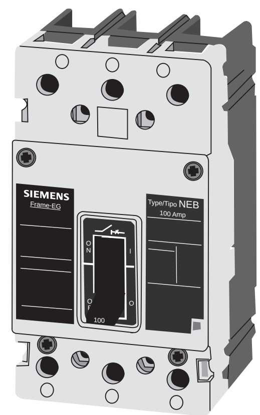
Adjustments Found on Some Circuit Breakers

Circuit Breaker Voltage Rating

Circuit breakers are rated according to the maximum voltage they can handle. The voltage rating is a function of the circuit breaker's ability to suppress the internal arc that occurs when the circuit breaker's contacts open.

The voltage rating of the circuit breaker must be at least equal to the circuit voltage. The voltage rating of a circuit breaker can be higher than the circuit voltage, but never lower. For example, a 480 VAC circuit breaker could be used in a 240 VAC circuit, but a 240 VAC circuit breaker could not be used in a 480 VAC circuit.

Some circuit breakers have what is referred to as a "slash" voltage rating, such as 120/240 VAC or, as shown in the following graphic, 600/347 VAC for 2, 3, or 4-pole NEB breakers and 115/250 VDC for 2-pole NEB breakers. In such cases, the breaker may be applied in a circuit where the nominal voltage between any conductor and ground does not exceed the lower rating and the nominal voltage between conductors does not exceed the higher rating.



NEB Circuit Breaker

			NEG	NEB	HEG	HEB
AC	Poles		1, 2, 3, 4	1, 2, 3	1, 2, 3, 4	1, 2, 3
	Amperes, Continous	1-Pole	15-125	15-125	15-125	15-125
		2-Pole	15-125	15-125	15-125	15-125
		3-Pole	15-125	15-125	15-125	15-125
		4-Pole	15-125	-	15-125	-
	Volts (50/60 Hertz)	1-Pole	347	347	347	347
		2-Pole				
		3-Pole	600/347	600/347	600/347	600/347
		4-Pole				
	UL Interrupting Rating - Symetrical RMS Amperes	240 V	85,000	85,000	100,000	100,000
		480V	35,000	35,000	65,000	65,000
		600/347 V	22,000	22,000	25,000	25,000
DC	Volts 2-Pole		125/250	125/250	125/250	125/250
	Interrupting Rating - DC Amperes		35,000	35,000	42,000	42,000

Circuit Breaker Continuous Current Rating

Every circuit breaker has a **continuous current rating** which is the maximum continuous current a circuit breaker is designed to carry without tripping. The current rating is sometimes referred to as the **ampere rating** because the unit of measure is amperes, or, more simply, amps.

The rated current for a circuit breaker is often represented as I_n, as shown in the following chart for an NEB circuit breaker. This should not be confused with the current setting (I_r) which applies to those circuit breakers that have a continuous current adjustment. I_r is the maximum continuous current that circuit breaker can carry without tripping for the given continuous current setting. I_r may be specified in amps or as a percentage of I_n.

Available Ampere Ratings (I_n)	
15 A	60 A
20 A	70 A
25 A	80 A
30 A	90 A
35 A	100 A
40 A	110 A
45 A	125 A
50 A	

			NEG	NEB	HEG	HEB
AC	Poles		1, 2, 3, 4	1, 2, 3	1, 2, 3, 4	1, 2, 3
	Amperes, Continous	1-Pole	15-125	15-125	15-125	15-125
		2-Pole	15-125	15-125	15-125	15-125
		3-Pole	15-125	15-125	15-125	15-125
		4-Pole	15-125	-	15-125	-
	Volts (50/60 Hertz)	1-Pole	347	347	347	347
		2-Pole	600/347	600/347	600/347	600/347
		3-Pole				
		4-Pole				
	UL Interrupting Rating - Symetrical RMS Amperes	240 V	85,000	85,000	100,000	100,000
		480V	35,000	35,000	65,000	65,000
		600/347 V	22,000	22,000	25,000	25,000
DC	Volts 2-Pole		125/250	125/250	125/250	125/250
	Interrupting Rating - DC Amperes		35,000	35,000	42,000	42,000

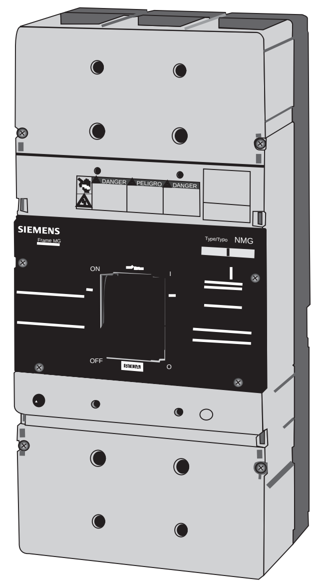
Conductors are rated for how much current they can carry continuously. This is commonly referred to as the conductor's **ampacity**. In general, the ampere rating of a circuit breaker and the ampacity of the associated conductors must be at least equal to the sum of any noncontinuous load current plus 125% of the continuous load current.

Siemens circuit breakers are rated on the basis of using 60° C or 75° C conductors. This means that even if a conductor with a higher temperature rating were used, the ampacity of the conductor must be figured on its 60° C or 75° C rating.

Circuit Breaker Frame Size

The circuit breaker frame includes all the various components that make up a circuit breaker except for the trip unit. For any given frame, circuit breakers with a range of current ratings can be manufactured by installing a different trip unit for each rating. The breaker **frame size** is the highest continuous current rating for a breaker with a given frame.

150 Amp Frame
Circuit Breaker



800 Amp Frame
Circuit Breaker

Circuit Breaker Interrupting Rating

Circuit breakers are also rated according to the maximum level of current they can interrupt. This is the **interrupting rating** or **ampere interrupting rating (AIR**). Because UL and IEC testing specifications are different, separate UL and IEC interrupting ratings are usually provided.

When designing a power distribution system, a main circuit breaker must be selected that can interrupt the largest potential fault current that can occur in the selected application. The interrupting ratings for branch circuit breakers must also be taken into consideration, but these interrupting ratings will depend upon whether series ratings can be applied.

The interrupting ratings for a circuit breaker are typically specified in **symmetrical RMS amperes** for specific rated voltages. As discussed in **Basics of Electricity**, RMS stands for root-mean-square and refers to the effective value of an alternating current or voltage. The term symmetrical indicates that the alternating current value specified is centered around zero and has equal positive and negative half cycles. Siemens circuit breakers have interrupting ratings from 10,000 to 200,000 amps.

The following table shows the UL interrupting ratings for type NEB circuit breakers. The ratings for other Siemens circuit breakers can be found in the SPEEDFAX catalog which is available in print form as well as on the Siemens web site.

Only UL Ratings Shown in this Example

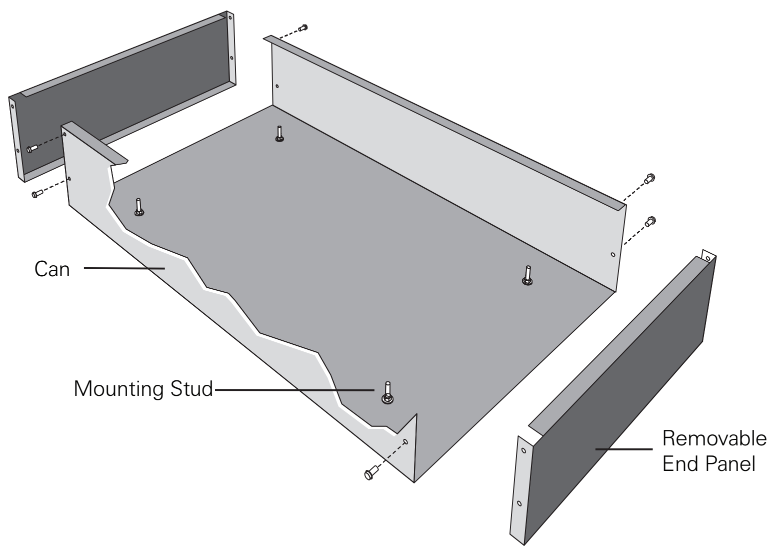
			NEG	NEB	HEG	HEB
AC	Poles		1, 2, 3, 4	1, 2, 3	1, 2, 3, 4	1, 2, 3
	Amperes, Continous	1-Pole	15-125	15-125	15-125	15-125
		2-Pole	15-125	15-125	15-125	15-125
		3-Pole	15-125	15-125	15-125	15-125
		4-Pole	15-125	-	15-125	-
	Volts (50/60 Hertz)	1-Pole	347	347	347	347
		2-Pole	600/347	600/347	600/347	600/347
		3-Pole				
		4-Pole				
	UL Interrupting Rating - Symetrical RMS Amperes	240 V	85,000	85,000	100,000	100,000
		480V	35,000	35,000	65,000	65,000
		600/347 V	22,000	22,000	25,000	25,000
DC	Volts 2-Pole		125/250	125/250	125/250	125/250
	Interrupting Rating - DC Amperes		35,000	35,000	42,000	42,000

Panelboard Construction

Panelboards are available in different sizes with variations in construction. The components that make up a panelboard, however, are similar. Panelboards contain a can, interior, circuit protection devices, label, and trim.

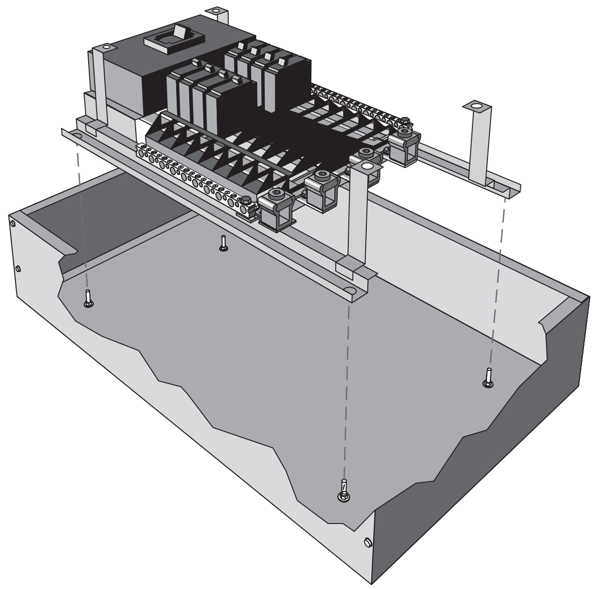
Can

The **can** is typically constructed of galvanized steel and houses the other components. The can is also referred to as a box or enclosure. It is designed to provide component and personnel protection. Removable blank end panels allow the user to cut whatever conduit holes are necessary. Pre-stamped knockouts are available as an option. Mounting studs are used to support the interior or group mounted devices.



Interior

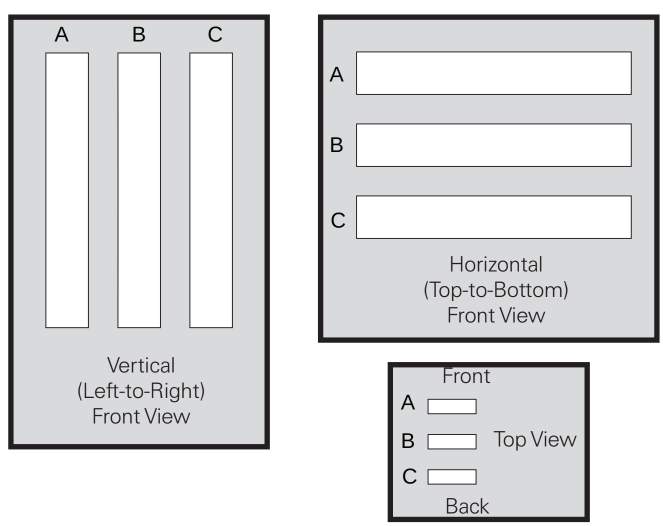
The **interior** consists of several components, including overcurrent protection devices, bus bars and insulated neutral bus bars. A lighting panel interior is mounted to the four mounting studs in the can. Jacking screws (not shown) allow adjustment of the interior within the enclosure.



Bus Bars

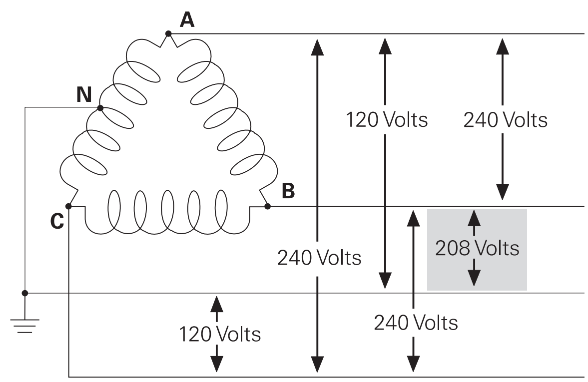
A bus bar is a conductor that serves as a common connection for two or more circuits. Standard bus bars on Siemens panelboards are made of aluminum, but copper bus bars are available as an option.

NEC ® Article 408 requires three-phase panelboard bus bars to have phases in sequence as shown in the following graphic so that an installer can have the same fixed phase arrangement in each termination point in a panelboard or switchboard. *NEC* ® Article 408 does provide an exception to this rule, refer to this article for additional details.

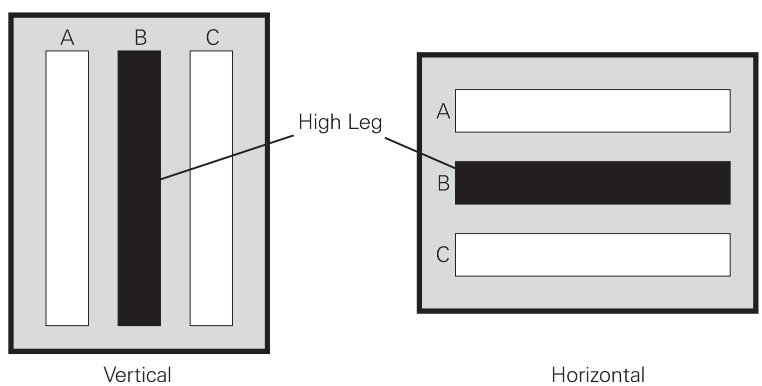


High Leg

Some power supply systems use a transformer with a three-phase, four-wire (3Ø4W), delta-connected secondary with grounded, center-tap connection on one phase. The following illustration shows an example of such a system with 240 volts phase-to-phase. The midpoint of one phase winding is grounded to provide 120 volts between phase A and neutral and 120 volts between phase C and neutral. Between phase B and neutral, however, the voltage is 208 volts. This is referred to as the **high leg**.

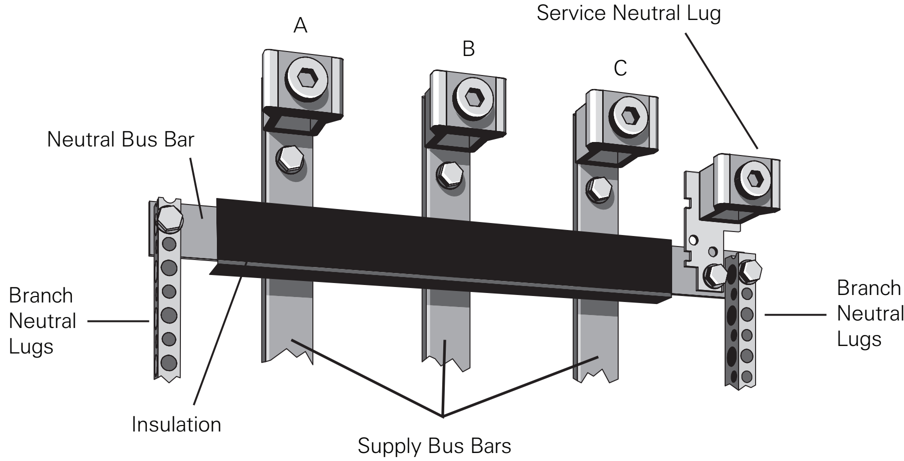


NEC® Article 110.15 requires that the high leg conductor or bus bar be permanently marked with an orange finish "or by other effective means." In addition, *NEC*® Article 408.3 states the **B phase** should be the high leg. Other bus bar arrangements are permitted for existing installations, but these arrangements must be marked. More information on calculating the value of the high leg, as well as connecting loads, is discussed later in the course.



Split Neutral

Siemens panelboards feature a **split neutral design** which means that neutral connections are available on both sides of the panelboard. Split neutrals are connected by means of an insulated neutral bus bar.

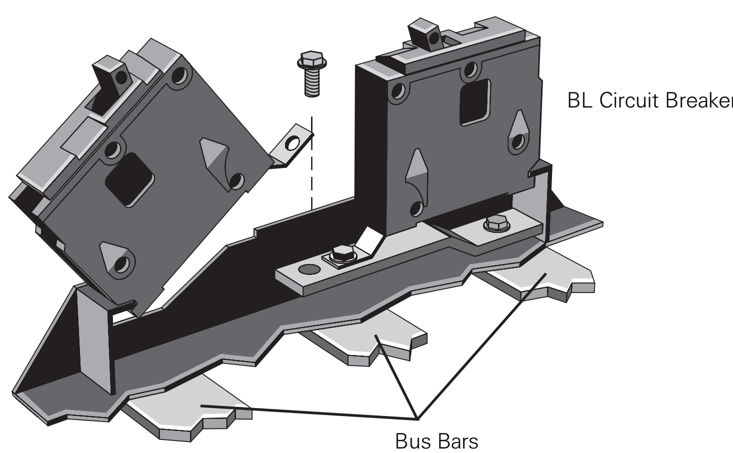


200% Neutral

Some loads can cause harmonics and non-linear loading on a distribution system. This requires special consideration when ordering a panelboard. One way to deal with non-linear loads is to double the capacity of the panelboard neutral. A **200% neutral** is an available option on Siemens panelboards.

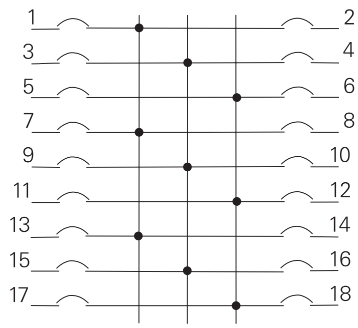
Circuit Protection Devices

While it is common for load centers to have plug-in branch circuit breakers, circuit breakers used in panelboards for commercial and industrial applications typically bolt on to the bus bars. For example, the following illustration shows two BL circuit breakers, one is mounted to the panelboard bus and the other is being mounted.

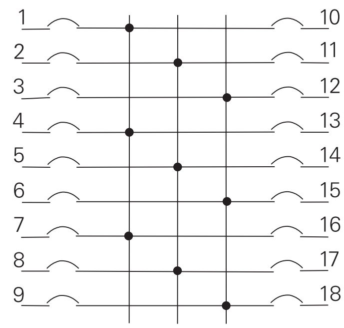


Circuit Identification

Specifications typically require panelboard circuit terminals to be labeled or for a wiring diagram to be provided. One approach for numbering terminals is to use odd numbers for poles on the panelboard's right (your left as you face the panelboard) and even numbers on the panelboard's left. This is sometimes referred to as NEMA numbering. For some specifications, vertical numbering is required.



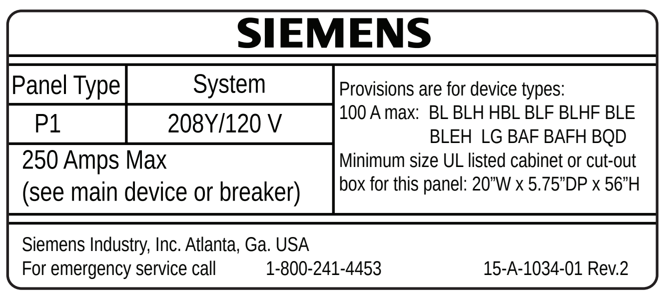
NEMA Numbering



Vertical Numbering

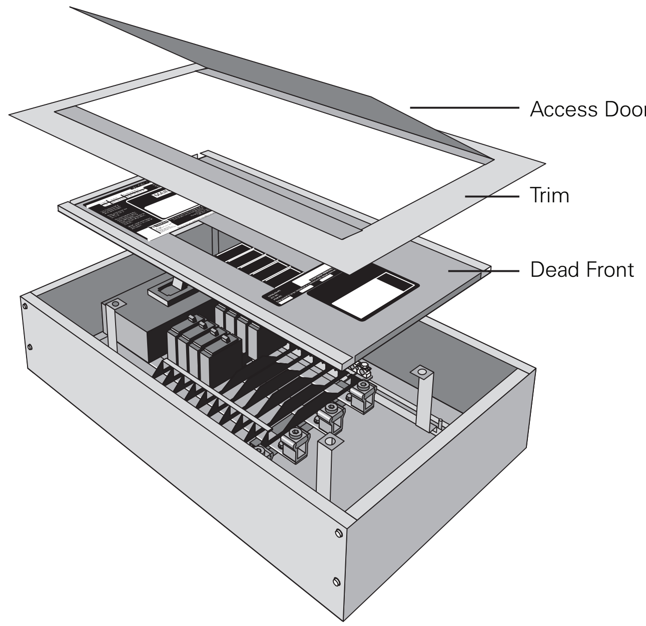
Panelboard Label

The **label** identifies the panelboard's type, voltage rating, and ampacity.



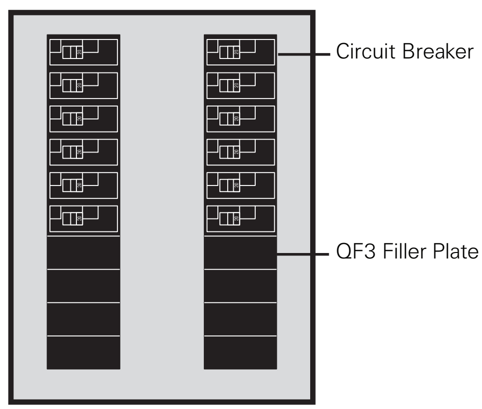
Dead Front and Trim

The **dead front** and **trim** are the front surfaces of the panelboard that cover the interior. The trim includes an access door. These components provide access to the overcurrent devices while sealing off the bus bars and internal wiring from contact.



Filler Plates

QF3 filler plates are used to cover any unused pole spaces not filled by a circuit breaker.



Enclosures

The National Electrical Manufacturers Association (NEMA) has established guidelines for electrical equipment enclosures. Siemens panelboards are supplied as standard in a **NEMA Type 1 enclosure** intended for general purpose indoor use.

The following enclosures are available as an option:

Type 3R Enclosures are intended for outdoor use primarily to provide a degree of protection against rain, sleet and damage from external ice formation.

Type 4X Enclosures are intended for indoor or outdoor use primarily to provide a degree of protection against corrosion, windblown dust and rain, splashing water, hose-directed water, and damage from external ice formation.

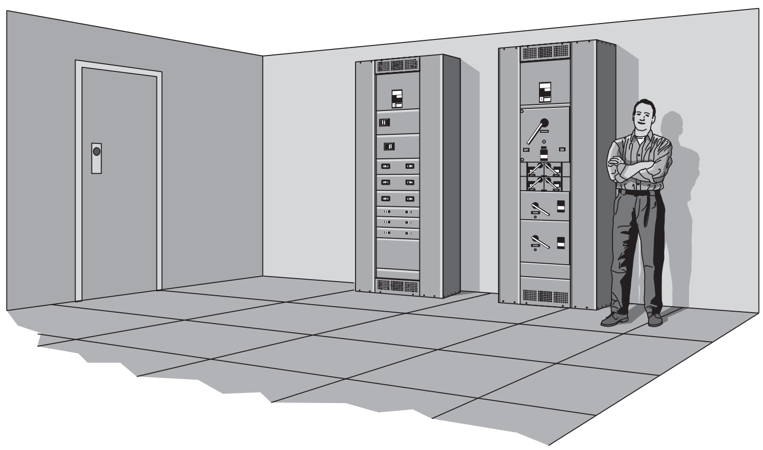
Type 3R/12 Enclosures are intended for indoor use primarily to provide a degree of protection against circulating dust, falling dirt, and dripping noncorrosive liquids.

Installation

Panelboard installation requires careful planning to ensure a safe environment for personnel and equipment. Article 110.26 of the *NEC*® covers spaces about electrical equipment, such as panelboards.

The intent of Article 110.26 is to provide enough **working space** for personnel to examine, adjust, service, and maintain energized equipment. Article 110.26 sets requirements for depth, width, and height of a working space.

In addition, Article 110.26 discusses entrance requirements to the working space as well as requirements for dedicated equipment space for indoor and outdoor applications. Refer to this article if you have questions about working space requirements.



Review 2

1. A ________ is the part of the panelboard enclosure that mounts in a wall (flush mounting) or to a wall (surface mounting).

2. A panelboard ________ consists of several components, including overcurrent protection devices, bus bars and insulated neutral bus bars.

3. A ________ is a conductor that serves as a common connection for two or more circuits.

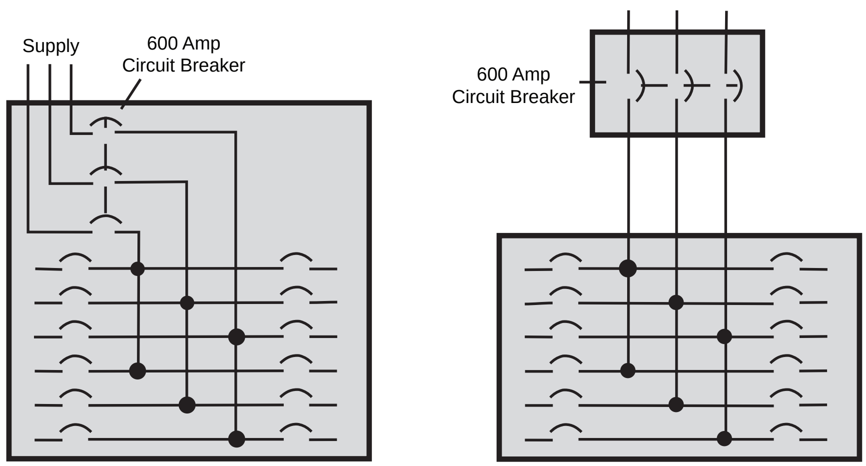
4. Siemens lighting panels feature a ________ neutral design, which means that neutral connections are available on both sides of the panelboard.

5. The ________ and ________ are the front surfaces of the panelboard that cover the interior.

Individual Overcurrent Protection

NEC® Article 408.36 requires panelboards to be protected by an overcurrent protection device with a rating that does not exceed the panelboard's rating.

The following illustration shows two ways individual panelboard overcurrent protection can be accomplished. A main overcurrent protection device, such as a circuit breaker, can be located as an integral part of the panelboard or located on the supply side of the panelboard. In this example, the main breaker and panelboard are both rated for 600 amps.



600 Amp Panelboard
Main Overcurrent Protection
is an Integral Part of the Panelboard

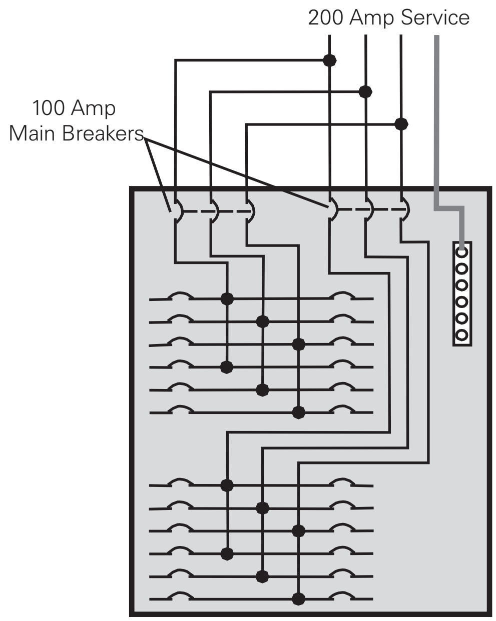
600 Amp Panelboard
Main Overcurrent Protection
is Remote from the Panelboard

NEC® Article 408.36 does provide for exceptions to this rule. Refer to the complete article and *NEC*® Article 230.71 for additional details.

Split Bus

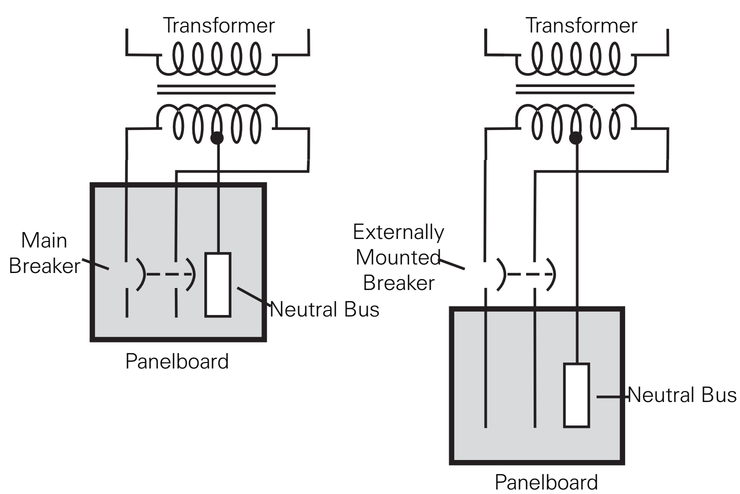
One of the exceptions to NEC® Article 408.36, allows panelboards to be protected by two main circuit breakers or two sets of fuses, provided that the combined current rating of these devices does not exceed the current rating of the panelboard.

When two main circuit breakers are used in a panelboard, a **split bus** is used. Half of the branch circuits are protected by one main circuit breaker, and the other half are protected by the other main circuit breaker. Keep in mind that the combined ratings for these circuit breakers must be no greater than the panelboard rating.



Panelboard Supplied by a Transformer

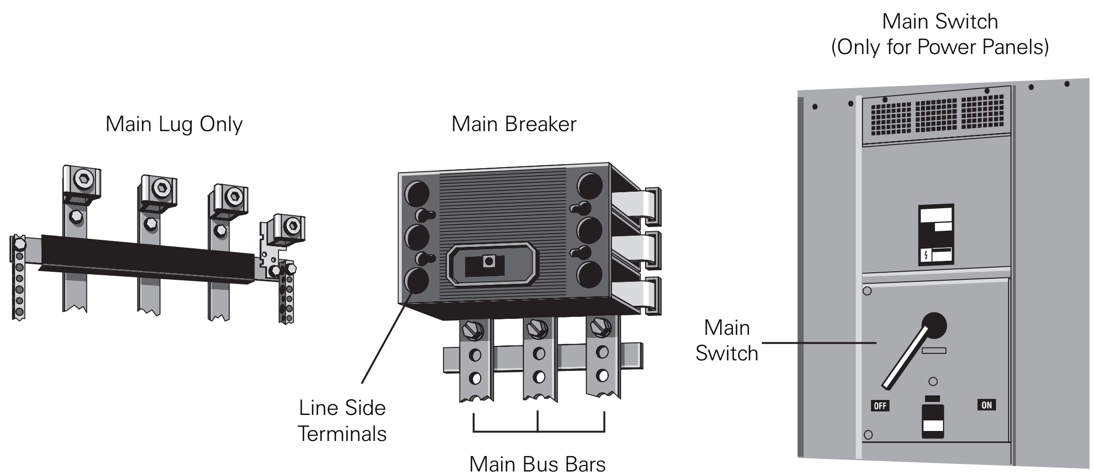
Frequently a panelboard is supplied by the secondary of a transformer. According to *NEC*® Article 408.36, individual protection for the panelboard must be provided on the secondary side of the transformer. The overcurrent protection device can be installed either ahead of or in the panelboard.



NEC® Article 408.36 (B) provides an exception to this rule. Refer to this article and Article 240.21 for additional details.

Panelboards Main Configurations

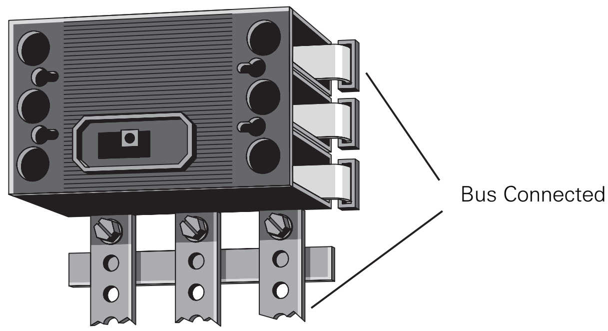
There are three types of panelboard main configurations: main lug only, main breaker, and main switch. In this context, the term switch refers to a fusible switch. All three of these configurations are available for power panels. Lighting panels are available with either a main lug only or a main breaker configuration.



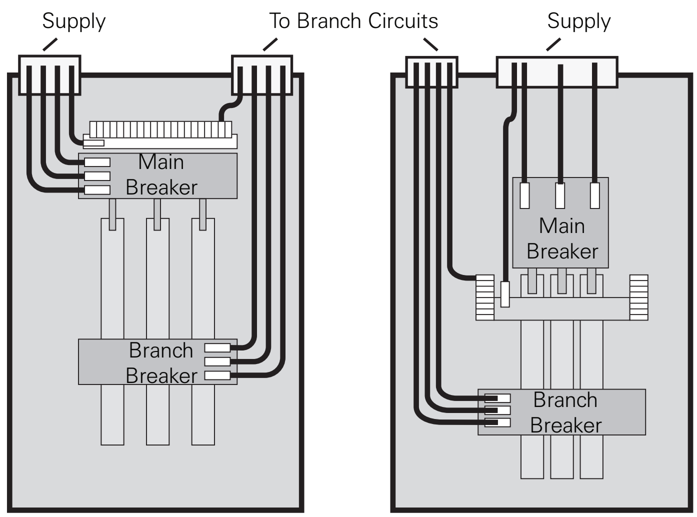
Main Breaker Panelboard

The incoming supply cables of a **main breaker type panelboard** are connected to the line side of the main breaker, which, in turn, feeds power to the panelboard and its branch circuits. The main breaker disconnects power from the panelboard and protects the system from short circuits, overloads, and ground faults (if equipped with ground fault protection).

Siemens main breakers are **bus connected** to the main bus bars. This means there are no cable connections required from the main circuit breaker to the lugs on the main bus bars. Bus connecting provides a higher degree of circuit integrity because there is less chance for loose connections which lead to overheating.



Depending on the panelboard, the main breaker can either be mounted horizontally or vertically.

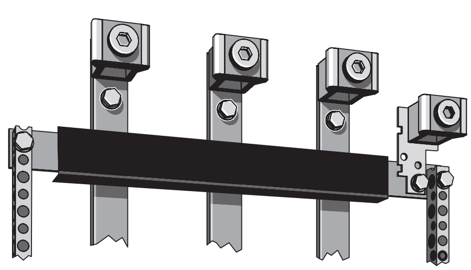


Main Breaker Mounted Horizontally

Main Breaker Mounted Vertically

Main Lug Only Panelboard

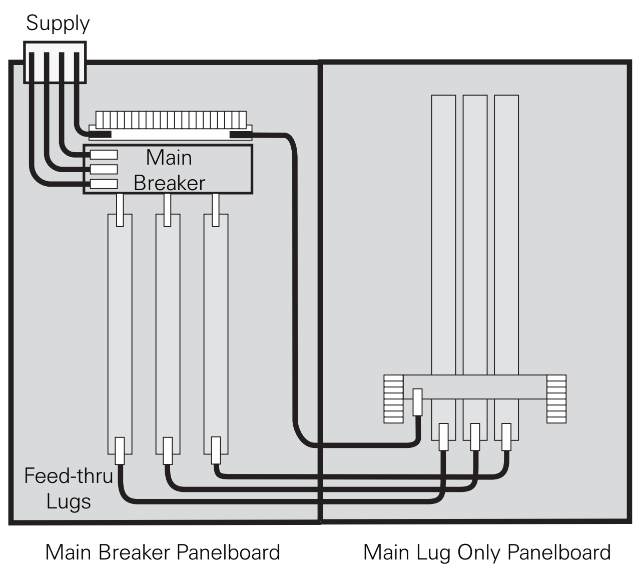
A **main lug only type panelboard** does not have a main circuit breaker. The incoming supply cables are connected directly to the bus bars. Primary overload protection for the panelboard is <u>not</u> provided as an integral part of the panelboard.



Feed-thru Lugs

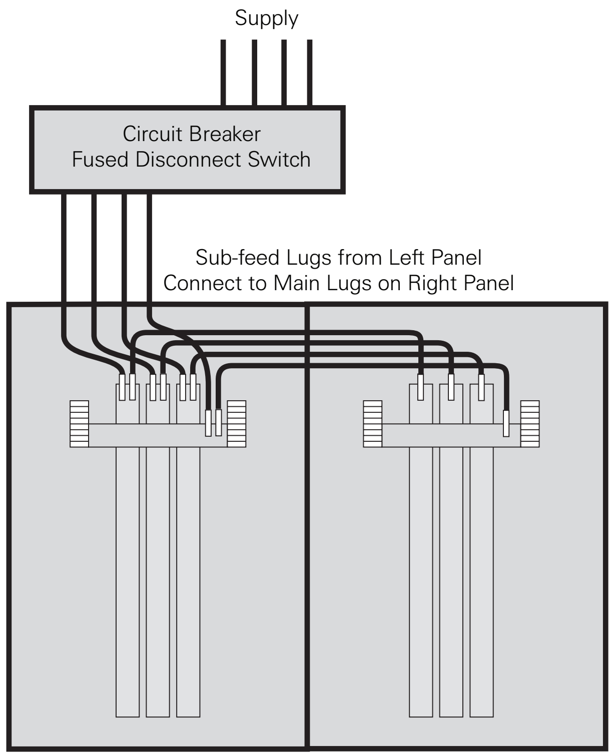
There are a variety of ways a main breaker or main lug only panelboard might be used in the same application. For example, **feed-thru lugs,** mounted on the opposite end of the main bus from the main breaker, could be used to connect a main breaker panelboard to a main lug only panelboard.

The feed-thru lugs mounted on the main bus of the main breaker panelboard are connected to the main lug only panelboard. The main breaker protects both panelboards from overcurrent.



Sub-feed Lugs

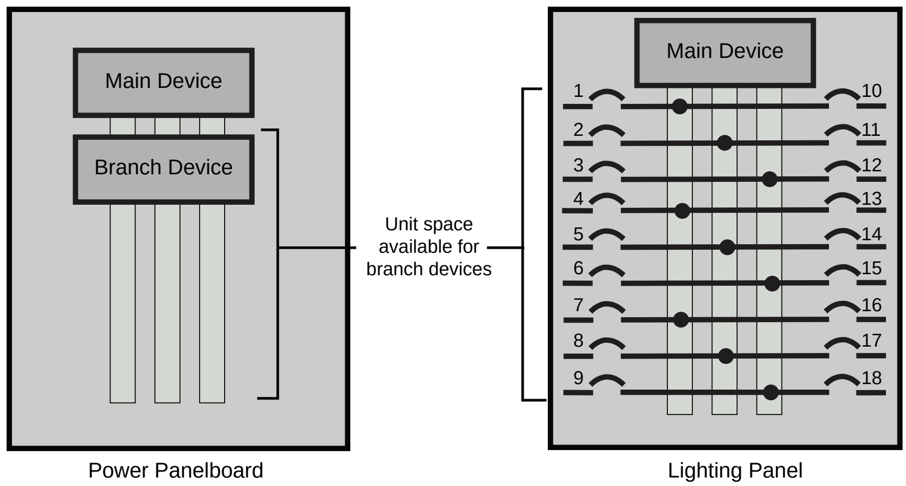
Sub-feed lugs are mounted directly beside the main incoming lugs on a panelboard and are used to connect one or more additional panelboards to the same feeder. In the example shown below, two adjacent main lug only panelboards are connected to the feeder through a fusible switch or circuit breaker. Power supplied by the overcurrent protection device is routed to the panelboard on the left and through sub-feed lugs to the panelboard on the right.



Unit Space and Number of Circuits

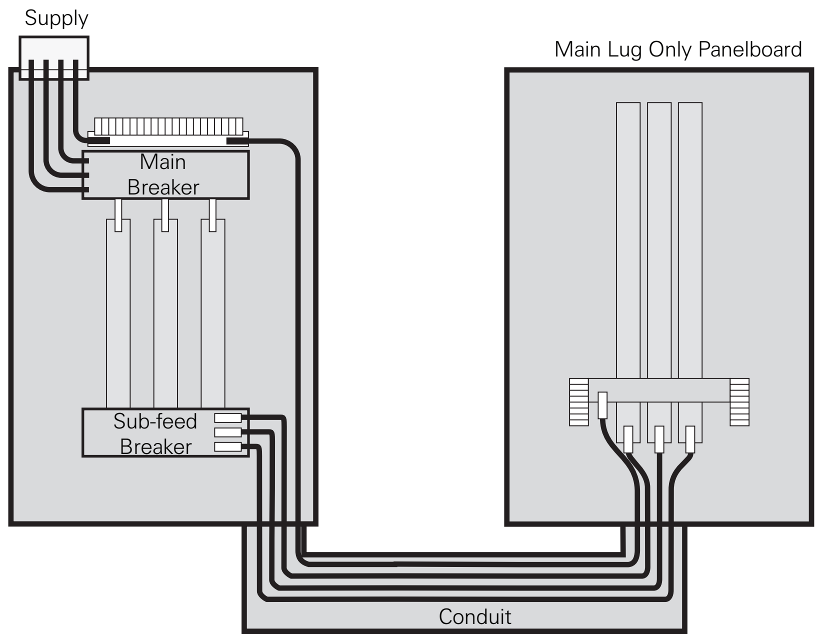
Circuit breaker or fusible switch mounting height is sometimes referred to as **unit space**. The unit space available for mounting branch devices depends on the panelboard type, enclosure dimensions, and main device configuration. Because the unit space required by circuit breakers and fusible switches varies, the number branch devices that can be mounted in a panel also varies.

For Siemens panelboards, the unit space available and the unit space required by each device can be found in the Speedfax catalog, which is available on the Siemens web site.



Sub-feed Breaker

When an application requires a circuit breaker that is a larger frame size than the branch circuit breakers available and will not fit in a branch circuit location, a **sub-feed breaker** can be used. One possible application is to supply a second panelboard located some distance from the first panelboard. However this is not the only application. A sub-feed breaker can supply any load that a branch circuit breaker can supply.



Review 3

1. The three types of panelboard main configurations are ________, ________, and ________.

2. The main breaker of a main breaker panel can be mounted _________ or ________.

3. Primary overload protection for a main _______ type panelboard is <u>not</u> provided as an integral part of the panelboard.

4. ________ lugs, mounted on the opposite end of the main bus from the main breaker, can be used to connect a main breaker panelboard to a main lug only panelboard.

5. _________ lugs are mounted directly beside a panelboard's main incoming lugs and are used to connect one or more additional panelboards to the same incoming feeder.

6. A ________ breaker can also be used to supply power to a second panelboard or a load that cannot be supplied by a branch breaker.

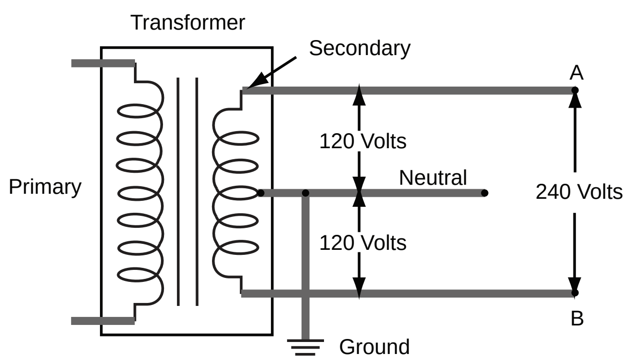
Power Supply Systems

Panelboards receive power from a variety of sources. For example, a downstream panelboard typically receives power from an upstream panelboard or switchboard. However, power for the distribution system originates from a utility power company. Power from the power company is stepped down through a transformer for distribution to a residential, commercial, or industrial facility.

There are a number of ways that the transformer secondary windings providing service may be configured. In order to properly select a panelboard, you need to understand which voltage and system will be connected. The following examples show a few of the more common systems, but other systems and voltages are also common.

1Ø3W Power System

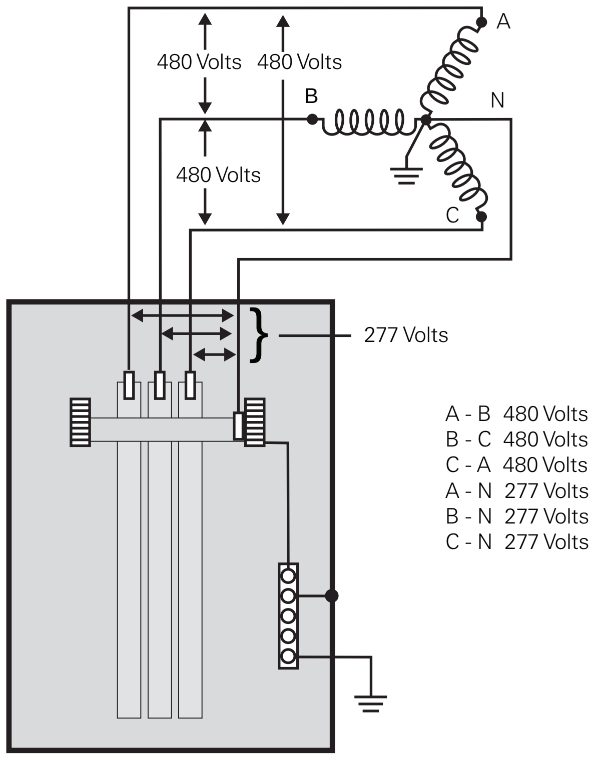
The following diagram illustrates a common single-phase, three-wire (**1Ø3W**) distribution system. As this diagram shows, the voltage between the neutral connection (N) of the transformer secondary and either side of the secondary is 120 V and the voltage across the entire secondary winding is 240 V.



3Ø4W Wye-connected Transformer

The following illustration shows the secondary of a 480 Y/277 V three-phase, four-wire (**3Ø4W**), wye-connected transformer. The "480 Y" indicates the transformer is wye-connected and has 480 volts between any two phases. The "277 V" indicates the voltage between any phase and neutral (N) is 277 V.

If you know the phase voltage for a system like this, you can calculate the phase-to-phase voltage by multiplying 1.732 times the phase-to-neutral voltage (277 V x 1.732 = 480 V).



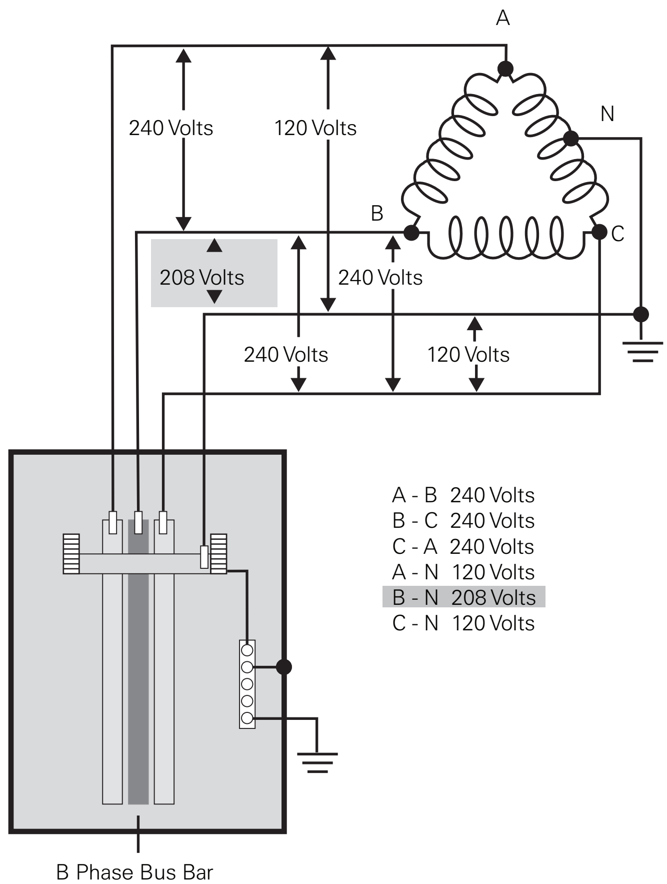
3Ø4W Delta-connected Transformer, BØ High Leg

A three-phase, four-wire (**3Ø4W**), delta-connected secondary works a little differently. The following illustration shows a delta-connected secondary with 240 V phase-to-phase. The midpoint of one phase winding is grounded to provide 120 V between phase A or C and the neutral connection. Between phase B and neutral, however, the voltage is 208 V. As previously discussed, this is referred to as the high leg.

Four-wire, delta-connected transformers are most often wired so that the B phase is the high leg. The high leg can be calculated by multiplying the phase A (or C) to neutral voltage times 1.732 (120 V x 1.732 = 208 V).

It is important to note that not all circuit breakers are suitable for use on the high leg. For example, breakers rated for 120/240 volts can be installed on legs rated for 120 volts, but cannot be installed on the high leg (208 volts).

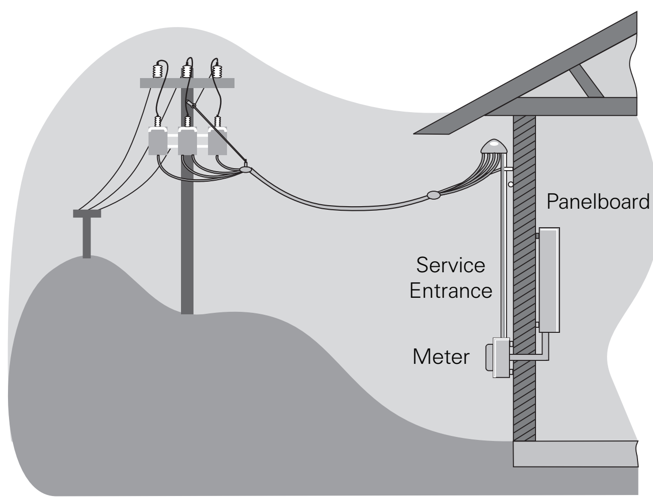
You may remember that *NEC®* Article 110.15 requires that the high leg bus bar or conductor be permanently marked with an orange finish "or by other effective means." This will help prevent someone from connecting a 120 V single-phase load to the 208 V high leg.



Service Entrance Panelboards

Sometimes panelboards are used as **service entrance equipment** for a building. This is the equipment located near where the power enters the building. The incoming power is connected to this equipment which provides a means to control and cut off the supply.

According to *NEC®* Article 408, panelboards used as service entrance equipment must be approved and labeled as such. Siemens offers panelboards that are factory labeled as **suitable for service entrance equipment** when *NEC®* requirements are met.



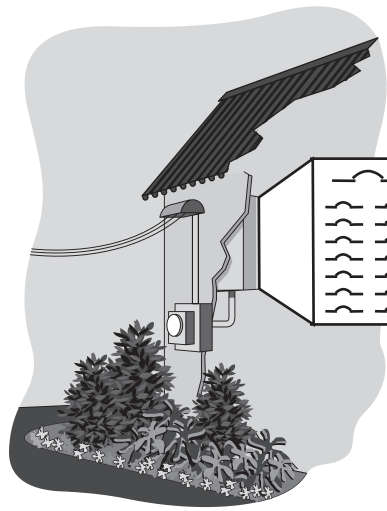
Maximum Number of Disconnects

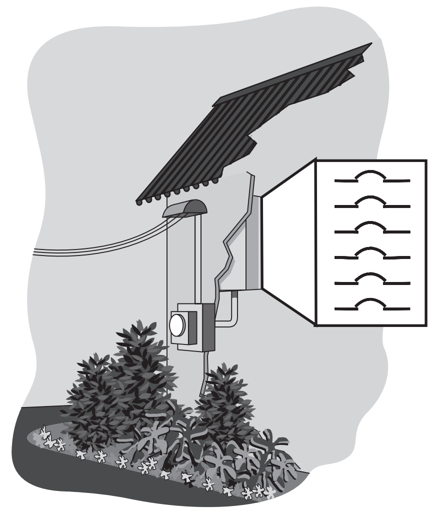
Service entrance conductors must have a readily accessible means of being disconnected from the power supply. *NEC®* Article 230.71 specifies that for each set of service entrance conductors no more than six switches or circuit breakers can be used to disconnect and isolate the service from all other equipment.

The following illustration shows two ways panelboards can be configured to meet this requirement. In the example on the left, a main breaker panelboard is used. In this example, a single main circuit breaker disconnects power to all equipment being supplied by the service.

In the example on the right, a main lug only panelboard is equipped with up to six circuit breakers to disconnect power to all equipment being supplied by the service.

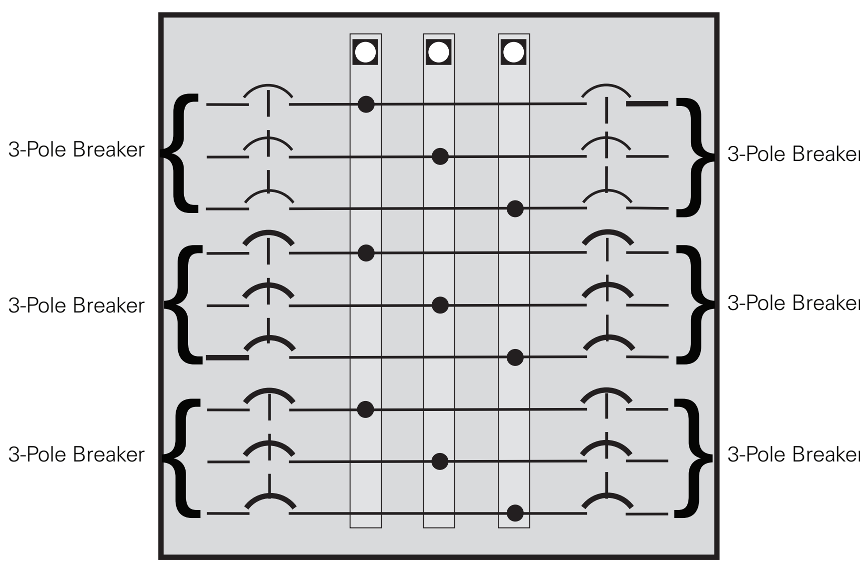
Regardless of which of these examples is used, each circuit breaker must be clearly labeled to show the load it supplies.


Main Breaker Panelboard with Branch Circuits


Main Lug Only Panelboard with Six Service DIsconnects

Disconnects Versus Poles

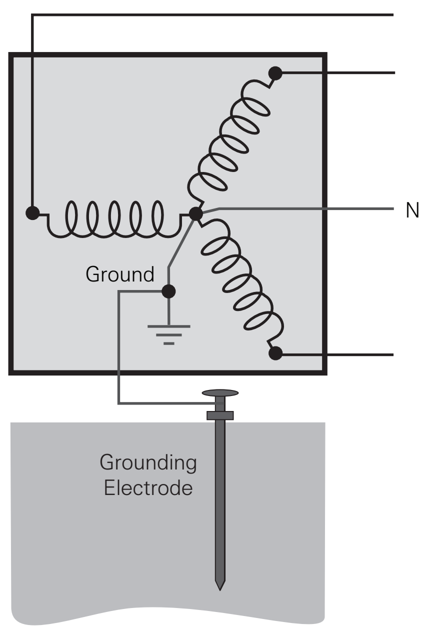
It is important to note that the six disconnect rule refers to the number of disconnects and not the number of poles. For example, the main lug only panelboard shown in the following illustration has 18 poles but only six circuit breakers. Three poles are mechanically linked together to form one disconnect device. Because the service can be disconnected with no more than six operations of the hand. This arrangement meets the six disconnect rule.



Panelboard Grounding

Grounding is an important aspect of any electrical equipment and must be considered carefully. A ground connection is a connection to earth or to a conductive object that is connected to earth. The accompanying illustration, for example, shows the neutral (N) conductor of a wye-connected transformer connected to ground.

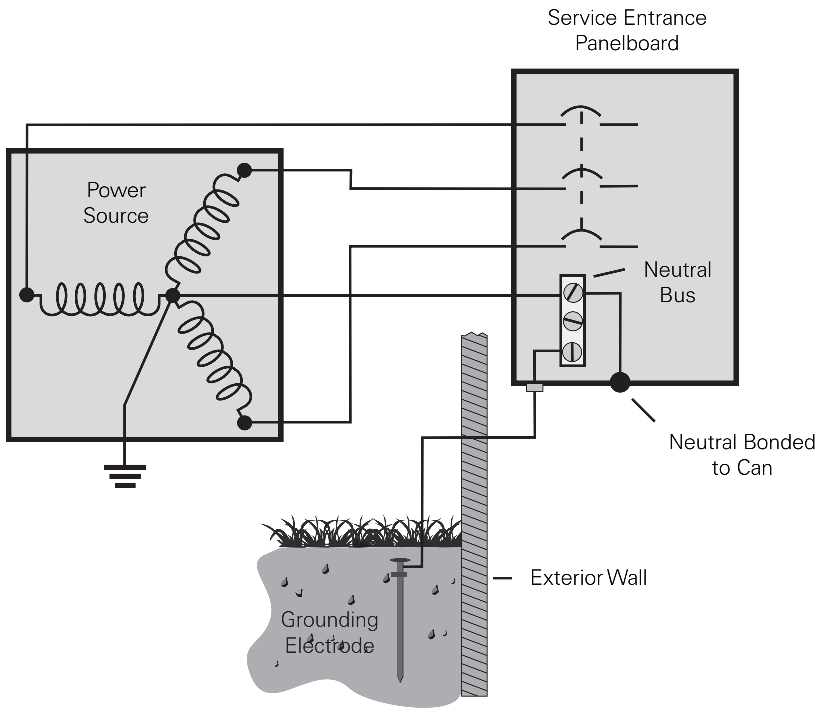
The intentional grounding of electrical equipment is done to limit voltage differences between parts of a system. This is necessary for the safety of personnel and the protection of equipment and facilities. Article 250 of the *NEC®* covers grounding and bonding requirements for electrical installations.



Service Entrance Grounding

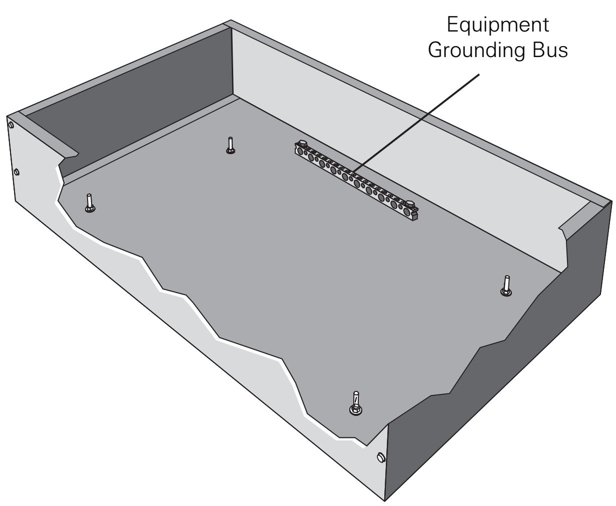
The panelboard neutral conductor is grounded only at the service entrance, never at any downstream equipment. In the following illustration, the neutral is grounded at the service equipment by connecting a conductor from the neutral (grounded conductor) to a grounding electrode.

The neutral and the panelboard enclosure are bonded together at the service entrance so that the enclosure is also connected to ground through the grounding electrode connector. **Bonding** permanently joins metal parts to form a low-resistance path for electrical current.



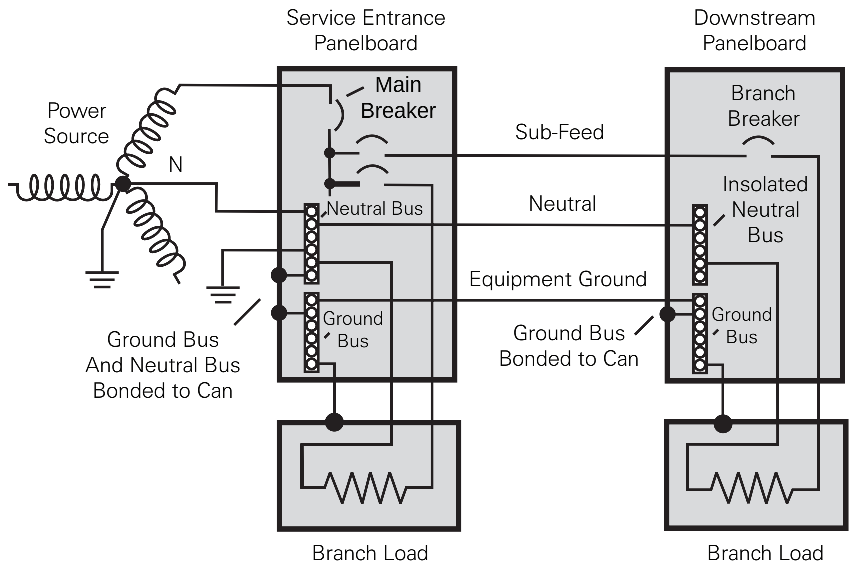
Equipment Grounding Bus

A panelboard may also require an **equipment grounding bus** which is non-insulated and mounted inside the panelboard directly to the can. All feeder and branch circuit equipment that are connected to the equipment grounding bus are at the same potential as the panelboard can. Siemens panelboards come with an equipment grounding bus.



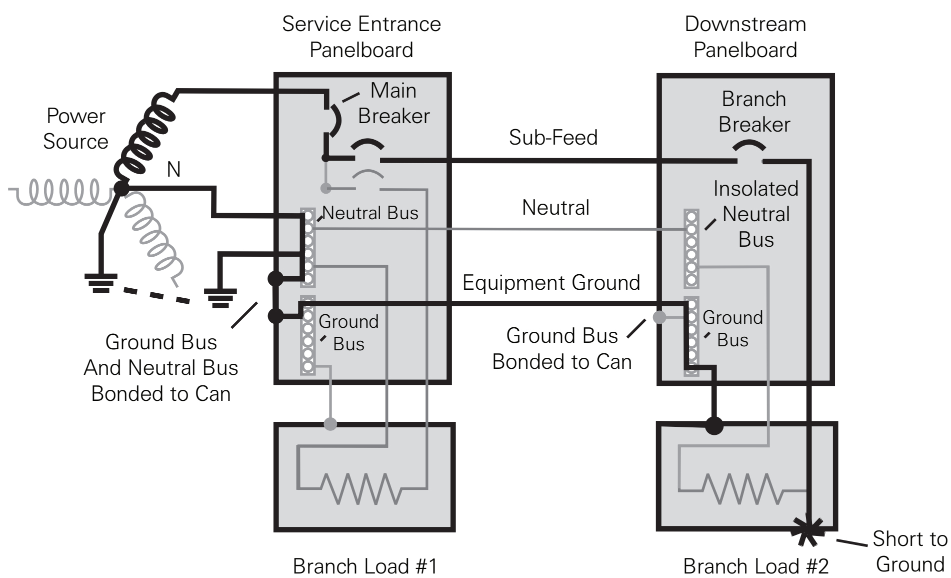
Grounding Panelboards Downstream

The neutral conductor is only connected to ground at the service entrance. As shown in the following illustration, when a downstream panel is used, the neutral is isolated from ground in that panel and connected to the neutral bus in the service entrance panel. In addition, the enclosure of the downstream panel is connected to ground through a grounding conductor which connects to the ground bus in the service entrance panel.



Fault Path

In the following illustration, load #2 has become shorted to its metal enclosure. Fault current is returned to the source through the path indicated. With a properly coordinated system, the branch circuit breaker in the downstream panelboard will open, removing the load from the power source.



Review 4

1. If the secondary of a four-wire, wye-connected transformer is 480 V phase-to-phase, the phase to neutral voltage is _____ V.

2. If the secondary of a four-wire, delta-connected, BØ high leg transformer is 240 volts phase-to-phase, determine the following phase to neutral voltages.

   _____ V from A-N
   _____ V from B-N
   _____ V from C-N

3. According to *NEC*® Article 230.71, the maximum number of disconnect devices that can be used to disconnect and isolate the service from all other equipment is ____ .

4. ________ permanently joins metal parts to form a low-resistance path for electrical current.

5. The ________ conductor is grounded only at the service entrance equipment, never at any downstream equipment.

Ground Fault Protection

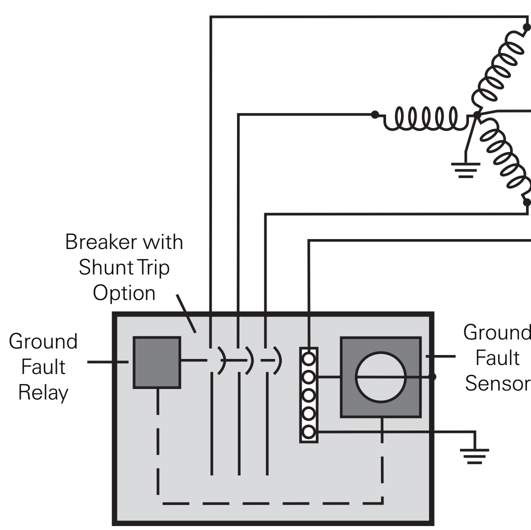
A **ground fault** is a condition in which electrical current unintentionally flows to ground. Because ground faults can cause damage to equipment and can endanger lives, ground fault protection is required in some situations.

For example, *NEC*® Article 230.95 requires **ground fault protection of equipment** for service disconnects rated 1000 amps or more on solidly-grounded wye services exceeding 150 volts-to-ground but not exceeding 600 volts phase-to-phase. Refer to the complete article for additional information.

Keep in mind that ground fault equipment protection must open a circuit when ground fault current reaches 30 milliamps. In contrast, ground fault circuit interrupters designed to provide life protection must open a circuit at 5 milliamps (plus or minus 1 milliamp). When ground fault protection is incorporated into a panelboard, it is generally through use of circuit breakers with ground fault protection.

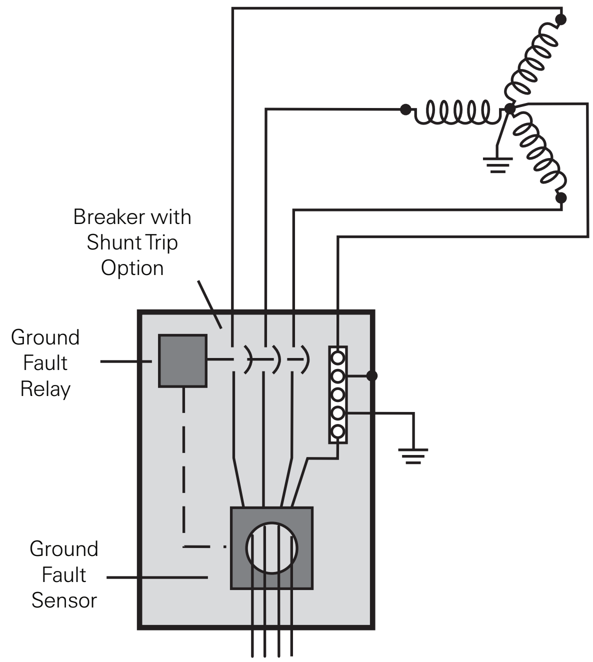
Ground Fault Sensor Around Bonding Jumper

One way a ground fault protector works is with a sensor around the insulated neutral bonding jumper. When an unbalanced current from a line-to-ground fault occurs, current will flow in the bonding jumper. When the current reaches a set level, the shunt trip opens the circuit breaker, removing the load from the line.



Ground Fault Sensor Around all Conductors

Another way a ground fault protector works is with a sensor around all the circuit conductors. When current is flowing normally, the sum of all the currents is zero. However, a ground fault causes an imbalance of the currents flowing in the individual conductors. When the imbalance reaches a set level, the shunt trip opens the circuit breaker, removing the load from the line.



Panelboard Interrupting Ratings

Interrupting Rating

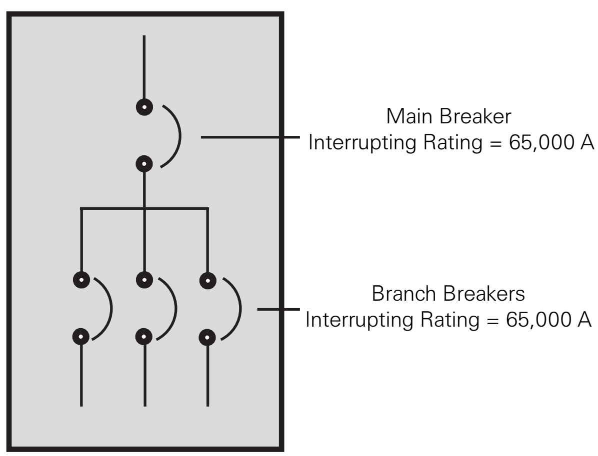
When selecting panelboards and overcurrent protection devices, it is essential to know the available fault current for an application and the interrupting rating for the protective devices under consideration for use in the panelboard.

NEC® Article 110.9 requires circuit protection equipment to have an **interrupting rating** sufficient for the circuit voltage and available current. There are two ways to achieve this requirement, **full rating method** and the **series rating method**.

Full Rating Method

The **full rating method** requires all circuit protection devices to have an interrupting rating equal to or greater than the available fault current.

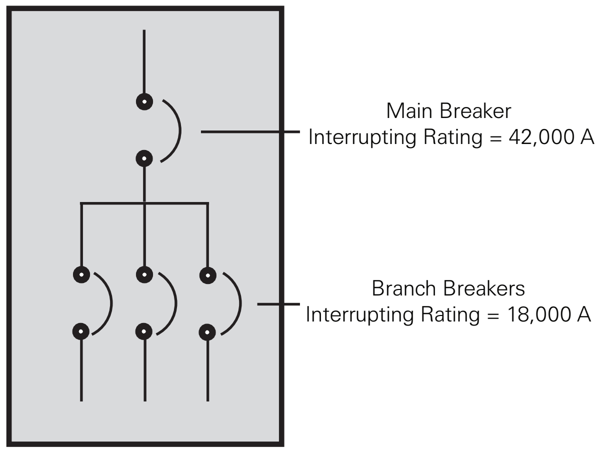
For example, in the case of a building with 65,000 amperes of fault current available at the service entrance, using the full rating method every circuit protection device must have an interrupting rating of 65,000 A. This example is shown in the following illustration. Note that the main circuit breaker and each branch breaker have an interrupting rating of 65,000 A.



Series Rating Method

An alterative to the full rating method is the series rating method, which requires that the main upstream circuit protection device must have an interrupting rating equal to or greater than the available fault current of the system, but subsequent downstream circuit protection devices connected in series can be rated at lower values.

For example, a building with 42,000 A of available fault current might have a breaker at the service entrance with an interruption rating of 42,000 A and additional downstream breakers rated at a lower level, but "sufficient for the current that must be interrupted," 18,000 A in this example.



Series Connected Short Circuit Rating

The series rating method is used when the selected series combination of circuit protection devices has been tested and certified by UL. Each series combination of circuit protection devices has a **series connected short circuit rating.** For additional information, refer to the Series Connected Short Circuit Ratings tables in the SPEEDFAX catalog.

Review 5

1. A ________ is a condition in which current unintentionally flows to ground.
2. *NEC*® Article 110.9 requires circuit protection equipment to have an ________ rating sufficient for the circuit voltage and available current.
3. The ________ rating method requires selecting circuit protection devices with individual interrupting ratings equal to or greater than the available fault current.
4. Series connected circuit breaker combinations must be tested and certified by ________.

Siemens P Series Panelboards

Siemens P series of panelboards offers a stepped approach to power distribution. The **P1** panel fits the majority of lighting panel needs in a cost effective package. P1 offers a flexible design that virtually eliminates the impact of common mistakes in feed direction or main lug versus main breaker selection. The next step in the series is the **P2** panel, which offers maximum flexibility and options to fit demanding specifications. **P3** is also a flexible and innovative panel. Sized more like a lighting panel for those tight areas, but with the power of a power distribution panel. **P4** is a mid-sized power distribution panel that can include fusible switches as well as circuit breaker main and branch devices. Finally, **P5** incorporates larger fusible and circuit breaker main and branch devices to provide maximum power to the distribution system.

Key Panelboard Features	P1	P2	P3	P4	P5
Lighting and Appliance Applications	●	●	●	●	●
Power Panelboard Applications	-	●	●	●	●
Convertible from Top Feed to Bottom Feed or Vice Versa	●	-	-	-	-
Change from Main Lug to Main Breaker or Add Subfeed Breaker Without Changing Enclosure Size	●	-	-	-	-
Space-saving, Horizontally Mounted Main Breaker	Up to 250 A	Up to 250 A	Up to 250 A	●	●
Short-circuit Rating Label Giving Performance Level	●	●	●	●	●
Standard Aluminum Ground Assembly	●	●	●	●	●
Blank End Walls Standard[1]	●	●	●	●	●
Bolted Current-carrying Parts	●	●	●	●	●
Split Neutral	●	●	●	●	●
Connection Accessible From Front	●	●	●	●	●
Screw-type Mechanical Lugs	●	●	●	●	●
Time-reducing Wing Nuts to Secure Interior Without Tools	●	●	●	●	●
Main And Branch Devices Connected With Case-hardened Hardware	●	●	●	●	●
Flush Lock, Concealed Door Hinges/Trim Screws	●	●	●	-	-
Symmetrical Interior Mounting Studs To Eliminate Upside-Down Mounting in Box	●	●	●	●	●
Interior Height Adjustment for Flush Applications	●	●	●	●	●
Mix and Match Fusible Switch Circuit Breaker Capability	-	-	-	●	●
Shallow Depth (Standard)	5.75"	5.75"	7.75"	10.00"	12.75"
Accepts A Wide Range of Fuse Types	-	-	-	●	●
Accepts Vacu-Break Fusible Switch	-	-	-	●	●
Accepts A Wide Range of Circuit Breakers	-	●	●	●	●
Optional Compression Lugs	●	●	●	●	●

● = Standard, - = Not Available

1. Knock-outs available on P1 and P2 5.75" deep x 20" wide boxes and P3 7.75" deep x 24" wide boxes.

General Specifications

P series panelboard interiors are designed to accommodate top or bottom feed. Regardless of which is specified for three-phase panels, branch device poles are arranged with the uppermost pole always on "A" phase, the second pole down always on "B" phase, and the third pole down always on "C" phase.

As a standard configuration, branch breakers are mounted at the top of the panel with "spaces" at the bottom, regardless of the direction the panel is fed.

The panel design provides bracing up to 200,000 A. Keep in mind that this is not the interrupting rating of the panel which depends on the circuit breaker configuration.

Description	P1	P2	P3	P4	P5
Max. Voltage	480Y/277V AC Max.	600V AC Max.	600V AC Max.	600V AC Max.	600V AC Max.
	250V DC Max.	500V DC Max.	500V DC Max.	500V DC Max.	500V DC Max.
System	1-phase, 2-wire	1-phase, 2-wire	1-phase, 2-wire	1-phase, 3-wire	1-phase, 3-wire
	1-phase, 3-wire	1-phase, 3-wire	1-phase, 3-wire	3-phase, 3-wire	3-phase, 3-wire
	3-phase, 3-wire	3-phase, 3-wire	3-phase, 3-wire	3-phase, 4-wire	3-phase, 4-wire
	3-phase, 4-wire	3-phase, 4-wire	3-phase, 4-wire		
Main Lugs	125-400A	125-600A	250-800A	400-1200A	800-1600A
Main Breaker	100-400A	100-600A	225-600A	400-800A	800-1200A
Main Switch	Not Applicable	Not Applicable	Not Applicable	100-200A	400-1200A
Branch Ratings	15-100A	15-225A	15-600A	15-600A Breaker	15-1200A Breaker
				30-200A Fusible	30-1200A Fusible

Enclosure Options

Description		P1	P2	P3	P4	P5
Box	Type 3R/12	●	●	●	●	●
	Type 4, 4X	●	●	●	●	●
	Drip Proof	●	●	●	●	●
	Drip Proof Hood Only	●	●	●	●	●
	Sealed Box	●	●	●	●	●
	Gasketed Trim	●	●	●	●	●
	Wider Box	●	●	●	●	●
	Deeper Box	-	●	●	●	●
Front	Hinged Door	●	●	●	●	●
	Door-in-Door Front	●	●	●	●	●
	Common Front	●	●	●	-	-
	Split Door	●	●	●	-	-
	Special Locks	●	●	●	●	●
	Nameplate	●	●	●	●	●

● = Option, - = Not Available

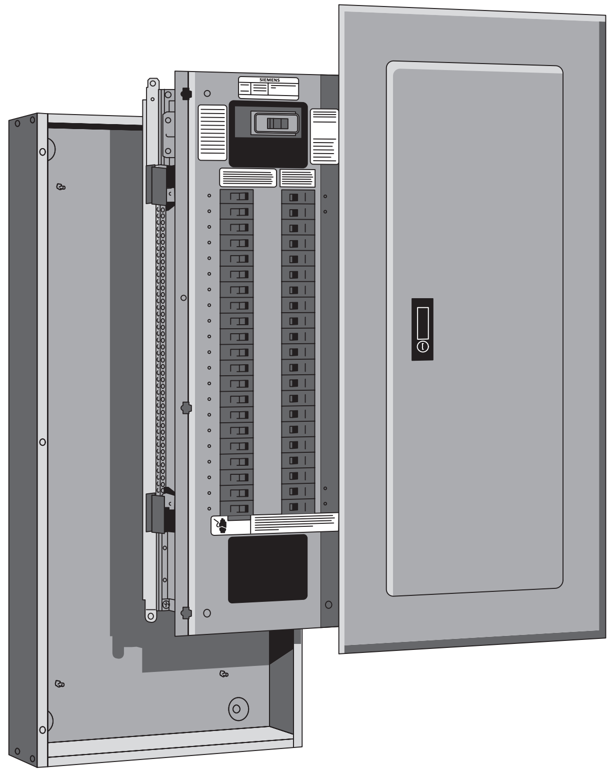
P1, P2, and P3 Panelboards

P1, P2, and P3 panelboards are grouped together in this section because they are similar in construction and function. Like all P series panelboards, these panels have symmetrical interior mounting studs to eliminate the problem of upside down mounting. P1, P2, and P3 panelboards feature concealed fasteners and hinges with a flush door lock. P1, P2, and P3 panelboards are designed to be wall mounted.

The standard bussing for P series panelboards is temperature rated aluminum with tin plating, but other bussing options are available.

P1 Panelboards

P1 panelboards are pre-engineered to accept the most common modifications without increasing box height.



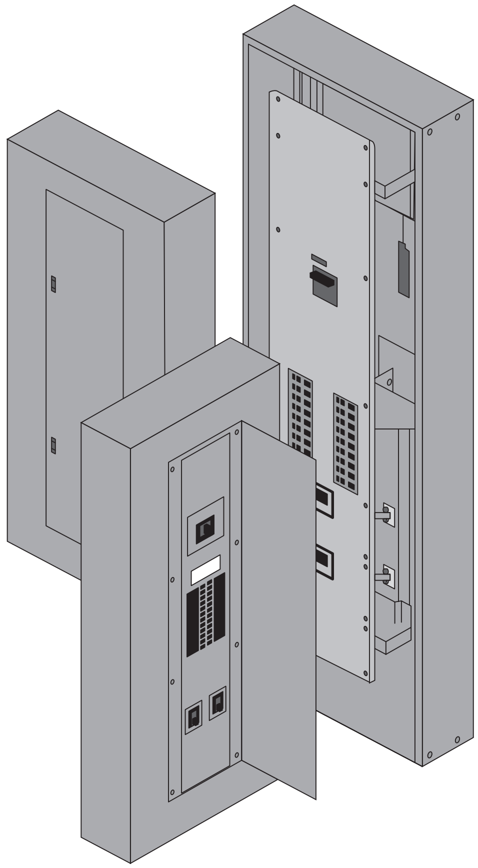
P1 Features

P1 panelboards have the following features:

- Symmetrical interiors - No top or bottom. To change from top to bottom or vice versa, simply invert the interior. The deadfront labeling is always right-side up.
- Field convertible from main lug to main breaker and vice versa with no increase in enclosure height.
- Field adaptability of feed-thru lugs or sub-feed circuit breaker without increasing enclosure height.
- Neutral system is field upgradeable to 200% capacity.
- Bonding provisions are shipped with each panel.
- Suitable for use as service entrance equipment (assuming *NEC®* compliance.)
- 250 V and 480 Y/277 V versions utilize identical boxes and fronts.
- Maximum number of circuits: 18, 30, or 42.

P2 Panelboards

P2 panelboards offer a wide variety of factory-assembled options to meet most lighting panel application requirements. The P2 design also offers the ability to mix breaker frames in unit space up to 250 A to meet many power distribution panel requirements in a much smaller package.



In addition to the standard bussing, P2 panelboard bussing options include temperature rated copper, 750 A/sq. in. aluminum, or 1000 A/sq. in. copper. Bussing is tin-plated, but silver-plated copper is available as an option. These bussing options also apply for P3, P4, and P5 panelboards.

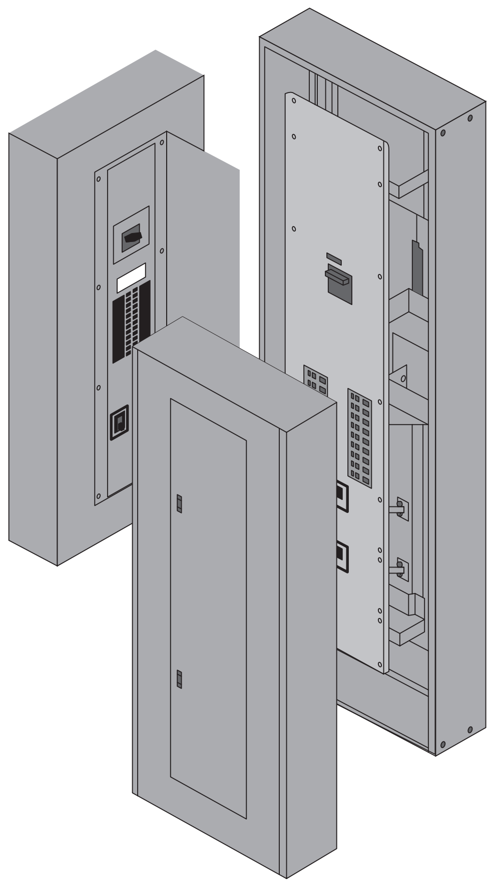
P2 panels are set up around 18, 30, 42, 54, 66, 78, and 90 circuit configurations. Blank unit space can also be added, if needed, to allow for future expansions or modifications.

P3 Panelboards

P3 panelboards are small footprint power distribution panelboards designed for use in applications that require more or larger branch devices than a lighting panelboard typically includes.

P3 panelboards can include a wide variety of factory assembled options and have the ability to mix and match breaker frames in unit space up to 250 A.

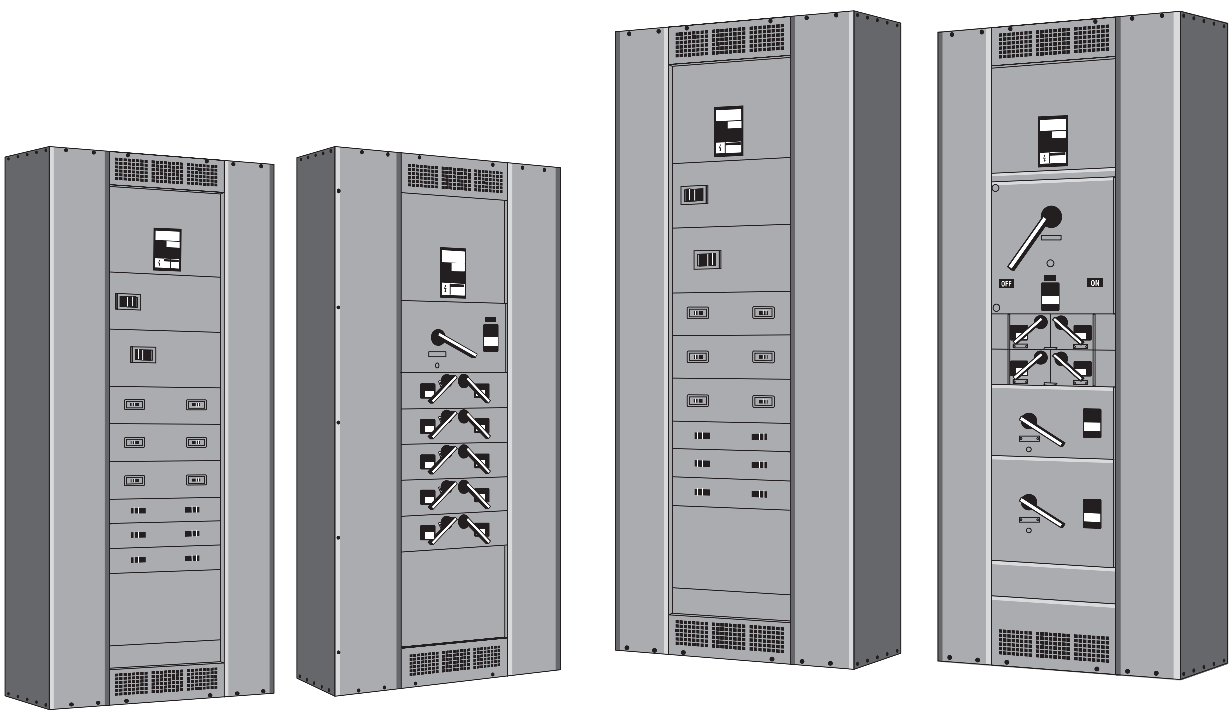
P3 panels are available with enclosure heights of 56, 62, 68, 74, or 80 inches. Like other power distribution panels, P3 panelboards can include blank spaces to allow for future expansions or modifications.



P4 and P5 Panelboards

P4 and P5 power panelboards are similar in design and features, but vary in the ratings available. P4 panelboards have a medium footprint to fit applications that require more or larger branch devices and higher current ratings than lighting and appliance panelboards can accommodate. P4 panelboards can incorporate circuit breaker frames in unit space up to 800 A and fusible switches up to 200 A.

P5 panelboards have the largest footprint of any P series panel, allowing even higher rated main and branch devices, including circuit breaker frames in unit space up to 1200 A and fusible switches up to 1200 A.



P Series Panelboard Catalog Numbers

The following P series panelboard catalog number description provides summary information. For more detail including information on circuit breaker selection, refer to the SPEEDFAX catalog.

The catalog number provides a description of the panelboard. There are eight parts to the standard P series panelboard catalog number as the example below shows.

1	2	3	4	5	6	7	8
P 1	C	4 2	F X	2 5 0	A	T	S

Part 1

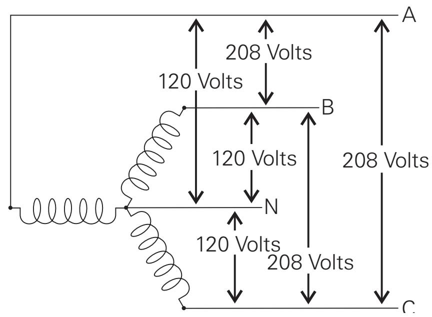
Part 1 identifies the type of panel, P1, P2, P3, P4, or P5. The sample panelboard catalog number shown is a P1 panelboard.

Part 2

Part 2 identifies the voltage and system. The following table shows voltage and system configurations available.

C	208Y/120 3Ø4W Wye AC - All	R	415/240 3Ø4W Wye AC - All
E	480Y/277 3Ø4W Wye AC - All	S	440/250 3Ø4W Wye AC - All
D	240 3Ø3W Delta AC - All	L	600/347 3Ø4W Wye AC - All
F	480 3Ø3W Delta AC - P2, P3, P4, P5	T	230 3Ø3W Delta AC - All
G	600 3Ø3W Delta AC - P2, P3, P4, P5	W	380 3Ø3W Delta AC - P2, P3, P4, P5
I	347 3Ø3W Delta AC - P2, P3, P4, P5	1	24V DC 1 Pole Branches Only (3) - All
B	240/120 3Ø4W Delta BØ High Leg AC - All	2	24V DC 2 Pole Branches Only (3) - All
Q	240/120 3Ø4W Delta CØ High Leg AC - P2, P3, P4, P5	3	48 V DC 1 Pole Branches Only (3) - All
X	120/240 2Ø5W Single Neutral AC - P2, P3, P4, P5	4	48 V DC 2 Pole Branches Only (3) - All
A	120/240 1Ø3W Grounded Neutral AC (2) - All	5	125 V DC 1 Pole Branches Only (3) - All
H	120 1Ø2W Grounded Neutral AC (2) - All	N	125 V DC 2 Pole Branches Only - All
J	240 1Ø2W No Neutral AC (3) - All	O	125/250V DC 2 Pole Branches Only - All
Y	125 1Ø2W Grounded Neutal AC (2) - P2, P3, P4, P5	P	125/250V DC 2 & 3 Pole Branches - All
Z	500 2W DC - P2, P3, P4, P5	U	120V AC 3Ø3W - All
K	220/127 3Ø4W Wye AC - All	V	240V 3Ø3W Grounded BØ - All
M	380/220 3Ø4W Wye AC - All		

The panelboard identified in the example is configured for a 208Y/120V, 3Ø4W power system. This indicates it is rated for a 208 volt wye-connected secondary. There are 208 volts phase-to-phase and 120 volts phase-to-neutral. It is a 3-phase (3Ø) 4-wire (4W) system.



Part 3

Part 3 indicates the number of circuits in a P1 or P2 type panelboard. If the panelboard is a P3, P4, or P5 type, this number represents the enclosure height in inches. In this example, the panelboard is a P1 with 42 circuits.

Part 4

Part 4 indicates whether the panelboard is a main breaker (2-digit code varies for each different circuit breaker), main lug (ML) or main switch (MS). In this example, FX indicates that the panelboard has an FXD6 main breaker.

Part 5

Part 5 indicates the panelboard current rating. In this example, the panelboard is rated for 250 amps.

Part 6

Part 6 indicates the bus material. The following table shows bus materials available. In this example, A indicates that the panelboard has standard temperature rated aluminum bus bars with tin plating.

Bus Code	Bus Material	Bus Plating	P1	P2	P3	P4	P5
A	Temp. Rated Aluminum	Tin Plated	●	●	●	●	●
B	750 A/sq. in. Aluminum	Tin Plated	N/A	●	●	●	●
C	Temp. Rated Copper	Tin Plated	●	●	●	N/A	N/A
E	Temp. Rated Copper	Silver Plated	N/A	Optional	Optional	●	●
F	Temp. Rated Copper	Tin Plated	N/A	●	●	●	●
G	1000 A/sq. in. Copper	Tin Plated	N/A	●	●	Optional	Optional
H	1000 A/sq. in. Copper	Tin Plated	N/A	Optional	Optional	●	●

● = Default for this bus type, N/A = Not Available

Part 7

Part 7 indicates whether feed location is from the top (T) or bottom (B). In this example, the panelboard is top fed.

Part 8

Part 8 indicates whether the panelboard is surface mounted (S) or flush mounted (F). In this example, the panelboard is surface mounted.

You can minimize the potential for error when ordering panelboards by making sure that you have the correct answers to the following questions.

- What is the power system (voltage, phases, number of wires)?
- What is the interrupting rating required for the panel?
- Which NEMA type enclosure is required?
- How many circuits are required for a P1 or P2 panel or what will the enclosure height be for a P3, P4, or P5 panel?
- Does the panelboard need to be suitable for service entrance? Suitable for use on service entrance (SUSE) labels are available, provided NEC® requirements are met.
- What type of main will the panelboard require: main lug only, main breaker, or main switch?
- If the panelboard will be a main breaker or main switch type, which main breaker or switch will be used?
- What amperage rating is required for the panel?
- What type of bussing is required?
- Will the panelboard be top or bottom fed?
- Will the panelboard be surface mounted or flush mounted?
- Which branch device types and how many devices of each type are needed.
- Which accessories are needed?
- What special modifications are needed?
- When will the equipment be needed?

Review 6

1. ___ panelboards can be converted from main lug to main breaker panels or vice versa in the field.

2. Standard bussing for P series panelboards is temperature rated ________ with ________ plating.

3. P2 panelboards are set up around 18, 30, 42, 54, __, __, and __ circuit configurations.

4. ___ and ___ panelboards can accept fusible switches as main and branch devices.

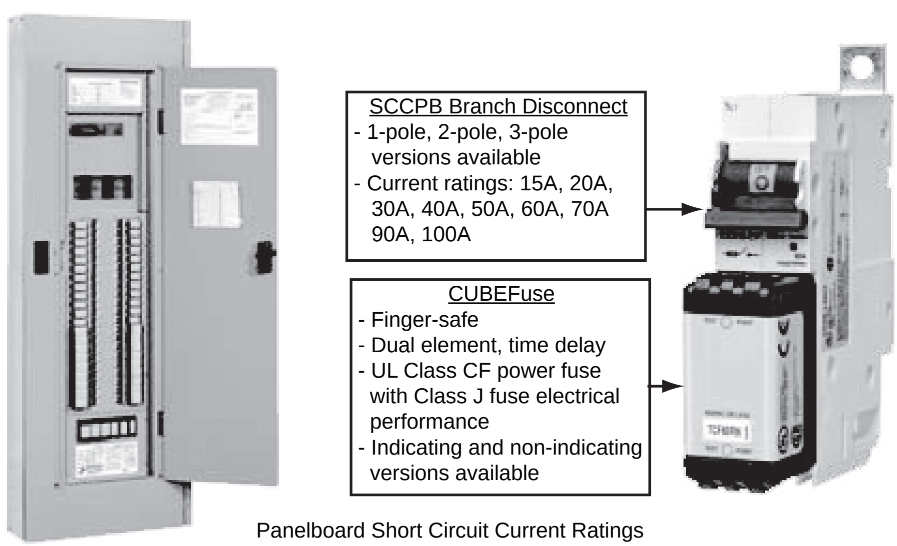
5. Fusible switches used in P series panels are either ________ or HCP switches depending on the required ratings.

6. A P series panelboard part number ending in TF indicates that the panelboard is _____ fed and _______ mounted.

Quick-Spec Coordination Panelboards

Siemens **Quick-Spec coordination panelboards** provide fusible solutions that make it simple and cost effective to selectively coordinate a fused electrical distribution system. These panelboards are designed to address the *NEC*® selective coordination requirements. Selective coordination is a highly desirable design consideration for many businesses because selectively coordinated overcurrent protective devices help avoid unnecessary blackouts that negatively affect business assets and productivity. Siemens coordination panels are especially designed for use in emergency systems, legally required standby systems, healthcare essential electrical systems, and critical operation power systems.

- Voltage Ratings: 600VAC, 125VDC
- Current Ratings: 30A, 60A, 100A, 200A, 225A, 400A
- Main Options: Main lug only, fused main disconnect, non-fused main disconnect
- Branch Circuit Positions: 18, 30, 42
- Neutral Options: Unbonded and bonded 200A, 400A, 800A
- Ground Options: Isolated and non-isolated
- Enclosures: NEMA 1 and NEMA 3R



Panelboard Short Circuit Current Ratings

	AC Main Options				DC Main
	Main Lug Only[1]	70-200A main disc. No fuses[1] or with Class J Fuses	225-400A main disc. No fuses[1] or with Class J Fuses	SCCP_CF main disc. (60A)[2]	Main lug only[1]
High	200kA	200kA	100kA	200kA	100kA
Standard	50kA	50kA	50kA	50kA	20kA

1. Class J, t, or RK1 fuses upstream, max. amps = panel amps
2. CUBEFuse disconnect

Additional Types of Panels and Cabinets

In addition to the P series and coordination panelboards described in this course, Siemens also offers C1 and C2 column type panelboards, lighting control panels, and telephone and equipment cabinets.

Siemens **C1 and C2 panelboards** have a narrow width suitable for column mounting. C1 panelboards are designed for a 250 VAC maximum supply and C2 panelboards are designed for a 480Y/277 VAC maximum supply. Both panels are designed for 250 A mains and can be main breaker or main lug only.

C1/C2 Panelboard

Siemens **lighting control panels** have been designed to make lighting control accessible for any building, whether the need is as narrow as an on-off switch or as complicated as a fully networked series of control panels sequencing on-off schemes across many floors.

Siemens **telephone and equipment cabinets** are 5.75″ deep, 20″ or 24″ wide, and vary in height from 23″ to 59″. These cabinets feature Siemens FAS latch fronts with concealed hinges and fastening screws.

For additional information about these additional panels and cabinets or other products described in this course, refer to the SPEEDFAX catalog which is available on the Siemens web site.

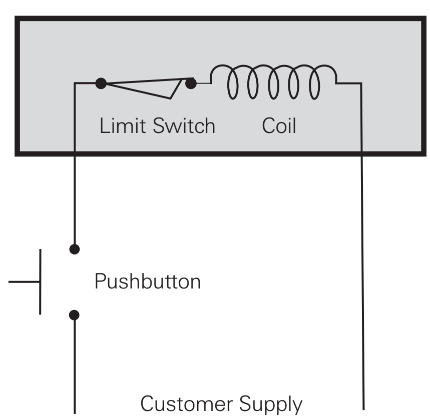
Accessories

Accessories add to the performance of a panelboard or adapt the panelboard for specific application requirements. Various accessories are available for Siemens panelboards. The shunt trip accessory described on this page is just one example of a circuit breaker accessory. Refer to the SPEEDFAX catalog for a complete listing.

Shunt Trip

Some accessories modify the circuit breaker. For example, it is sometimes necessary to trip a breaker from a remote location. This capability might be required for a variety of reasons, such as when it is necessary to have a "panic button" that de-energizes machinery for safety reasons. One way to accomplish this is to provide power to the machinery through a circuit breaker equipped with a **shunt trip accessory**.

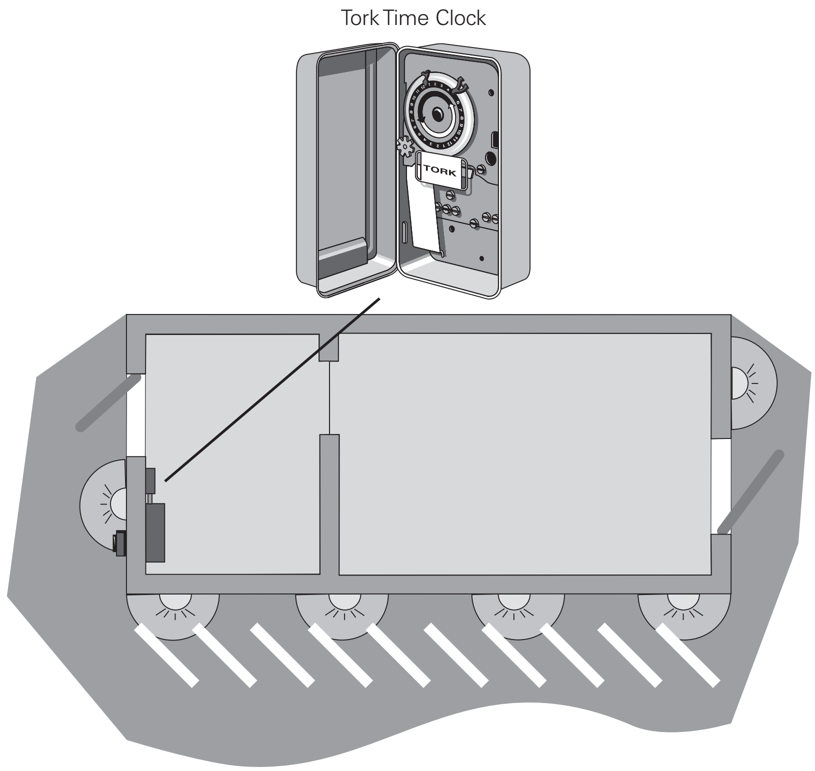
The shunt trip may be part of the main breaker, which will shut off the entire panelboard, or part of a branch breaker. The shunt trip device consists of a coil in series with a limit switch. When the circuit breaker contacts are closed, the limit switch is closed. Depressing a customer-supplied pushbutton energizes the shunt trip coil, causing the breaker's mechanical latch to disengage the trip mechanism and opening the circuit breaker's contacts. When the circuit breaker's contacts open, the limit switch also opens, removing power from the shunt trip coil. As with any trip, the breaker must be reset manually.



Time Clocks

Tork, Sangamo or Paragon time clocks are available as an external accessory for P1 panelboards and can be mounted internally in P2, P3, P4, or P5 panelboards. Time clocks are available in 1 or 2-pole, single or double throw devices, or 3-pole, single throw. They are rated for a maximum of 277 volts.

A time clock can be used to turn a branch circuit or an entire panelboard on and off at predetermined times. In the following illustration, for example, a time clock connected to a panelboard is used to turn outside lights for a small commercial building on and off.



Remote Control Switches

When an application requires remote control of loads, an **ASCO 911 or 920 mechanically-held remote control switch** or Siemens **LEN electrically-held contactor** can be mounted in a separate cabinet as a main disconnect.

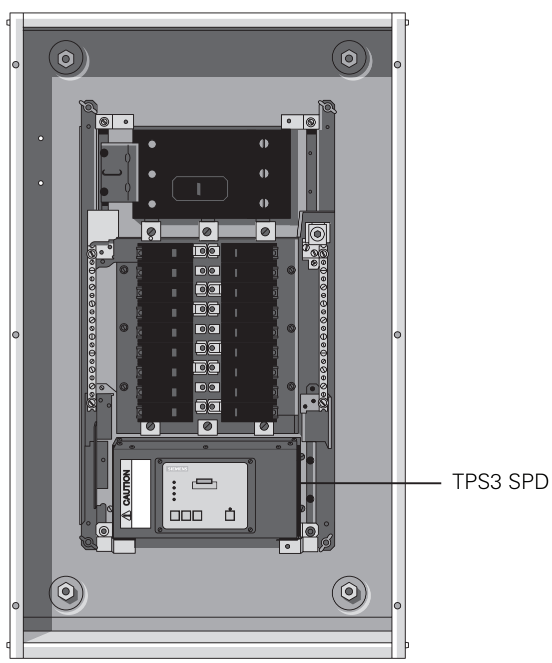
TPS3 Transient Protection Systems

Many electrical devices and systems are susceptible to damage from the high energy levels associated with electrical surges caused by lightning or other electrical equipment. Any component between the source of the surge and ground can be damaged. Therefore, electrical systems aren't complete unless they incorporate surge protection. Surge protection is best accomplished by stopping surges before they get in through the application of hard-wired **surge protection devices (SPDs)** installed at key electrical system surge entry points.

Siemens **TPS3 SPDs** are designed to the UL 1449 3rd edition standard for hard-wired SPDs. TPS3 SPDs provide the highest degree of safety while delivering some of the industry's best performance ratings. Siemens TPS3 family of commercial SPDs share common performance parameters and are offered in two configurations: integral SPDs (designed into our distribution equipment) and external or wall-mounted SPDs.

TPS3 options are available for Siemens panelboards and other distribution equipment. One example of an integral TPS3 SPD is a P1 panelboard option that bolts directly to the panelboard bus bars. Once installed, LEDs indicate that the device is working and provide voltage and diagnostic monitoring. There is an audible alarm and test button. Options include a surge counter and a remote monitoring device.

P1 Panel with TPS3 SPD



Power Meters

In today's complex business climate, power monitoring systems often require meters with a range of capabilities from basic energy and power meters to advanced power quality meters that can accumulate data from a variety of sources. In addition, while small systems often need low-cost, stand-alone meters, the growing demands for energy management and overall monitoring of system performance mean that communication with a variety of devices is increasingly important.

Fortunately, Siemens offers a complete range of energy, power, and power quality metering products to meet virtually any power monitoring system requirement. The Siemens SENTRON PAC series of meters can be installed in P2, P3, P4, and P5 panelboards. In addition to the PAC series of meters, the Siemens 9000 series of meters can be installed in P4 and P5 panelboards.

Embedded Sub-Metering Solutions

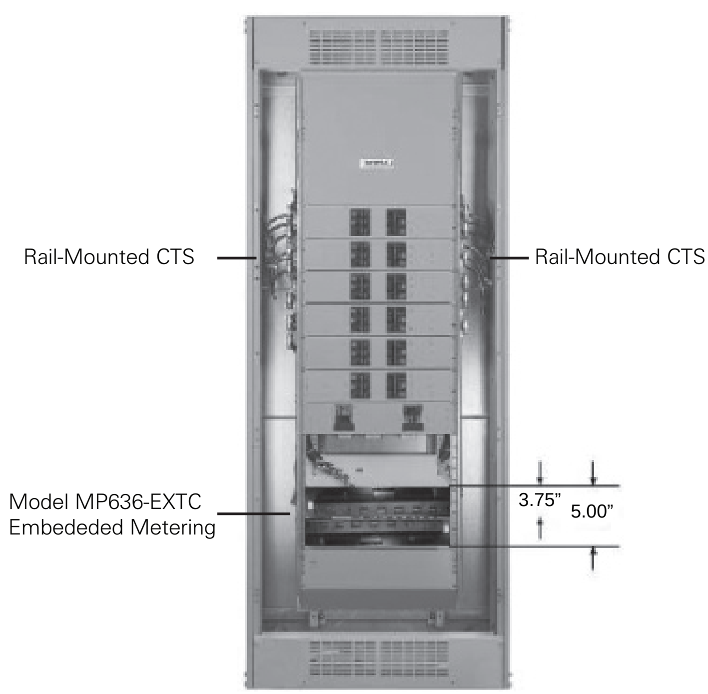
In a world where tenant square footage is a premium in commercial building designs, the area for electrical metering is being drastically reduced. At the same time, contractor labor costs for the installation of sub-metering systems continues to increase.

To meet these sub-metering challenges, Siemens offers proven cost-effective solutions for embedded metering and monitoring. These solutions combine a fully-integrated metering system factory installed in Siemens switchboards and P series panelboards. Along with the required local or remote sub-billing software, this provides a total sub-metering system.

When compared to the typical wall-mounted socket metering installations, considerable savings in space, installation costs, and data collection are realized with Siemens embedded metering solutions.

The typical embedded metering design consists of:

- Rail mounted CTs that communicate to a central metering unit mounted in unit space
- One 15 amp 3-pole breaker to power the units and obtain a voltage reference
- Built-in communications



P5 Panelboards with Model MP626EXTC Embedded Metering Solution

Review 7

1. Siemens ________ panelboards provide fusible solutions that make it simple and cost effective to selectively coordinate a fused electrical distribution system.

2. Siemens ________ and ________ panelboards have a narrow width suitable for column mounting.

3. A ________ is a circuit breaker accessory designed to trip a breaker from a remote location.

4. Siemens ________ family of commercial SPDs share common performance parameters and are offered in two configurations: integral SPDs (designed into our distribution equipment) and external or wall-mounted SPDs.

5. ________ are available as an external accessory for P1 panelboards or mounted internally in P2, P3, P4, or P5 panelboards when an application requires a panelboard to be turned on and off at predetermined times.

6. ________ meters can be installed in P2, P3, P4, and P5 panelboards and a range of other Siemens meters can be installed in P4 and P5 panelboards.

7. When compared to the typical wall-mounted socket metering installations, considerable savings in space, installation costs, and data collection are realized with Siemens ________.

Review Answers

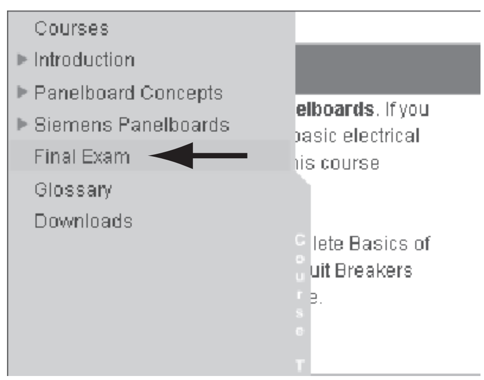
Review 1	1) power distribution; 2) b; 3) 2008.
Review 2	1) can; 2) interior; 3) bus bar; 4) split; 5) dead front, trim.
Review 3	1) man breaker, main lug only, main switch; 2) horizontally, vertically; 3) lug only; 4) Feed-thru; 5) Sub-feed; 6) sub-feed.
Review 4	1) 277; 2) 120 A-N, 208 B-N, 120 C-N; 3) 6; 4) Bonding; 5) neutral.
Review 5	1) ground fault; 2) interrupting; 3) full; 4) UL.
Review 6	1) P1; 2) aluminum, tin; 3) 66, 78, 90; 4) P4, P5; 5) Vacu-Break; 6) top, flush.
Review 7	1) Quick-Spec coordination; 2) C1, C2; 3) shunt trip; 4) TPS3; 5) Time clocks; 6) SENTRON PAC; 7) embedded sub-metering solutions.

Final Exam

Before taking the final exam, it is recommended that you delete the temporary internet files from your computer's web browser. For most versions of **Internet Explorer**, you can do this by selecting **Internet Options** from the **Tools** menu and then clicking on the **Delete Files** button. If you do not perform this step, you may see a score of 0% after you submit your exam for grading.

The final exam for this course is available online at **http://www.usa.siemens.com/step**. This web page provides links to all our quickSTEP online courses. To complete the final exam for this course, click on the **Basics of Panelboards** link.

Next, move your mouse over to the left so that the navigation bar pops out and select the **Final Exam** link. The final exam page will appear.



After you complete the final exam, click on the **Grade the Exam** button at the bottom of the page. Your score on the exam will be displayed along with the questions that you missed.

If you score 70% or better on the exam, you will be given two options for displaying and printing a certificate of completion. The **Print Certificate** option allows you to display and print the certificate without saving your score in our database and the **Save Score** option allows you to save your score and display and print your certificate. **The Save Score option is primarily intended for use by our distributors and Siemens employees.**